U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-257 796

Determination of Harmful Quantities and Rates of Penalty for Hazardous Substances. Volume IV

Battelle-Northwest, Richland, Wash Pacific Northwest Lab

Prepared for

Environmental Protection Agency, Washington, D C Office of Water Planning and Standards

Jan 75

BIBLIOGRAPHIC DATA SHEET

1. Report No.

2.

3. Recipient's Accession No. PB-257 796

4. Title and Subtitle

Determination of Harmful Quantities and Rates of Penalty for Hazardous Substances. Volume IV. Comparative Analysis

5. Report Date Jan 75

6.

7. Author(s)

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8. Performing Organization Rept. No. EPA/440/9 75/005d

9. Performing Organization Name and Address

Battelle-Northwest
Richland, Washington
Pacific Northwest Lab.

10. Project/Task/Work Unit No.

11. Contract/Grant No.

EPA-68-01-2268

12. Sponsoring Organization Name and Address

Environmental Protection Agency
Washington, D.C.
Office of Water Planning and Standards

13. Type of Report & Period Covered

14.

15. Supplementary Notes

Also available in set of 4 reports as PB-257 792-SET, PC$26.00/MF$6.00.

16. Abstracts

The three preceding volumes of this report describe in detail the development of four alternative technical approaches for the designation of harmful quantities and rates of penalty for nonremovable hazardous materials. All approaches were designed to comply with the law, but each offers unique features which vary the degree of resolution and ease of administration achieved. Each alternative is likely to have a different level of impact on potential spillers as well as the environment. It is these differences that must be characterized and considered as part of the final selection of an optimal approach. Volume IV has been written to address these and other issues.

17. Key Words and Document Analysis. **17a.** Descriptors

*Water pollution,
*Waterways(transportation),
*Hazardous materials,
*Law enforcement,
Comparison,
Sources,
Economic impact,
Insurance,
Legislation,
Industries,
Sulfuric acid,
Ammonia,
Chlorine,
Sodium hydroxide,
Benzene,
Phenol,
Motor vehicles,
Railroads,
Management planning,
Evaluation,
Criteria,
Litigation.

17b. Identifiers/Open-Ended Terms

*Fines,
Stationary sources,
Hazardous materials spills.

17c. COSATI Field/Group 13 B

18. Availability Statement

National Technical Information Service
Springfield, Virginia 22161

19. Security Class (This Report) UNCLASSIFIED

20. Security Class (This Page) UNCLASSIFIED

21. No. of Pages 218p

22. Price 7.75/3.00

FORM NTIS-35 (REV. 10-73) ENDORSED BY ANSI AND UNESCO. THIS FORM MAY BE REPRODUCED USCOMM-DC 8265-P74

EPA-440/9-75-005-d 272062

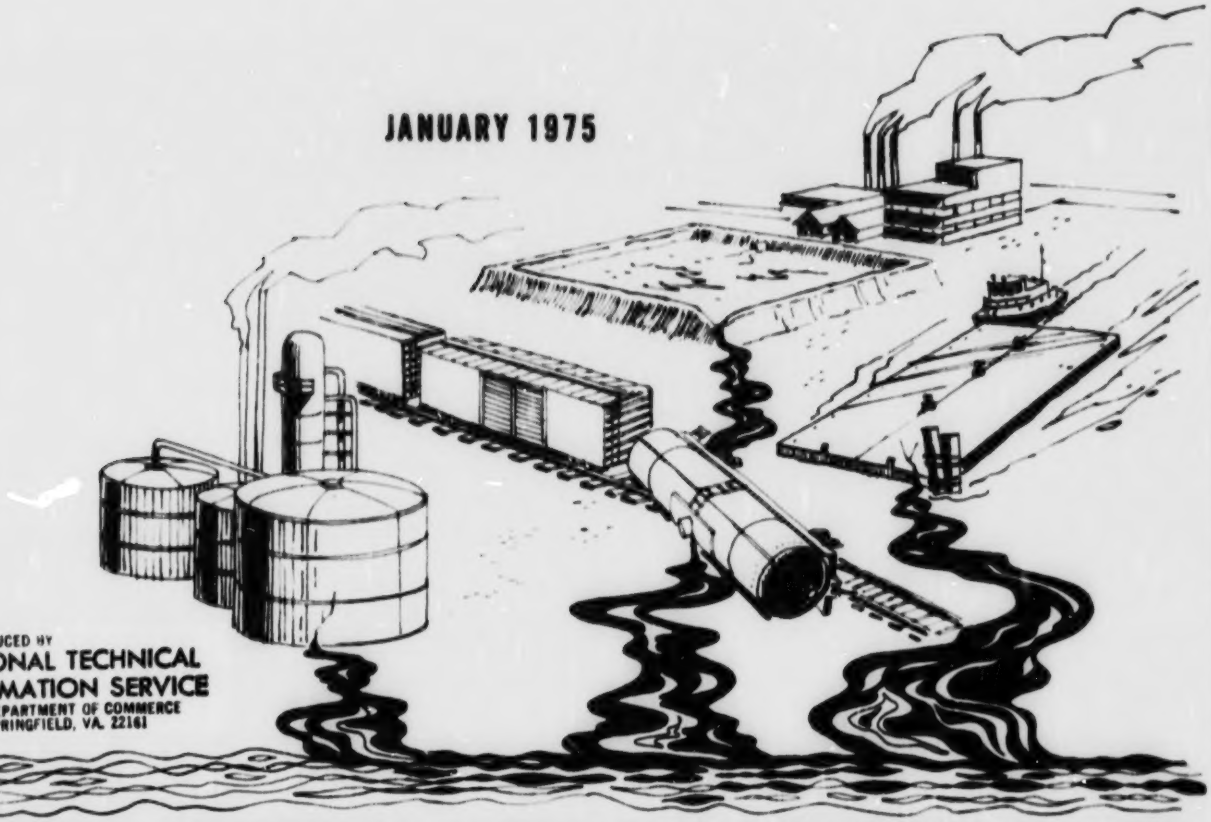
PB 257 796

FINAL REPORT

VOLUME IV - COMPARATIVE ANALYSIS

DETERMINATION OF HARMFUL QUANTITIES AND RATES OF PENALTY FOR HAZARDOUS SUBSTANCES

JANUARY 1975



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INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

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218

EPA-440/9-75-005-d

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JANUARY 1975

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OFFICE OF WATER PLANNING AND STANDARDS
U. S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D. C. 20460

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FOREWORD

This report was initiated by the Environmental Protection Agency to gather additional information and to complete several concepts developed by the technical staff of the Agency. This report is one of the series dealing with hazardous materials and the prevention and/or removal of spills of these materials into or upon the navigable waters of the United States. The methodologies were determined to be necessary to provide a technical basis for the development of regulations under Section 311 of Water Pollution Control Act as amended in 1972 (PL 92-500). This report is a result of several man years of work by the Government, industry, and the contractor. It should be understood that the methodologies explained here may be used in some modified form in regulations to be developed and/or revised as appropriate to implement Section 311.

This document should be regarded as a technical reference document which may be used as appropriate by this Agency and others primarily in the development of the regulatory control program for hazardous substance spills. The principal regulations for which these methodologies were developed are required to be promulgated under Section 311(b)(2)(B)(iv) and Section 311(b)(4) which require that penalty rates for nonremovable hazardous substances shall be prescribed and that quantities determined to be harmful to public health and welfare be identified. The other regulations as required by Section 311 dealing with hazardous substances involve: the designation and determination of removability; the determination of removal and mitigating methods; the determination of procedures and equipment for spill prevention; the determination of small facility spill clean-up liabilities; the determination of nonharmful quantities; and appropriate revision to the National Oil and Hazardous Substance Pollution Contingency Plan. This information is thought to be of use of assessing the environmental benefits and potential economic impacts in the development of regulations dealing with methods for removal and mitigation of hazardous substances and procedures and equipment for prevention of hazardous substance spills from transportation, production and use facilities.

At the time the project was conceived the Agency had participated in international hazardous material control negotiations and had gained considerable experience working with industry in the production, distribution and use of materials which may be designated as hazardous substances. Late in 1972 and early in 1973, it became the concern of this Agency that several alternative methods should be examined in detail to allow equitable regulatory development. This concern was keyed to be pending designation regulation which would list elements and compounds as hazardous substances.

It is anticipated that the information that has been gathered during this study which involved the National Hazardous Materials Conference in San Francisco, August 1974, and the Regulation Symposium in Washington, DC in October 1974 will be utilized in part in the development of regulations to be published in the Federal Register. Once the regulations are promulgated, going through the process of Advance Notice of Rule Making, Proposed Rule Making, and Final Promulgation, the program will be implemented nationwide. This program implementation is anticipated to be in conjunction with the United States Coast Guard and to be implemented at the EPA Region and Coast Guard District Level. It is further anticipated that areas for the Administrator's discretion in evaluating penalties may be established as appropriate through EPA Guidelines and/or Enforcement Regulations formulated by this Agency.

Particular thanks should be expressed to the primary authors of this Report with special emphasis to acknowledge the cooperation provided by the chemical manufacturing industry, the chemical transporting industry and others who supplied basic information upon which this study is built. An individual appreciation is expressed to Dr. Allen L. Jennings of the Hazardous and Toxic Substances Branch for his technical participation and enthusiasm is seeing this job completed. Others who helped in the review and editing for EPA included Dr. Gregory Kew, Messrs. Robert Sanford, James Cating, and Charles Gentry. It should be recognized that this project was possible due to the foresight in planning, funding, and the staff assistance of Messrs. Walter Miguez, Robert Suzuki, John Cox, and others of the Division of Oil and Special Materials, without whose help this project would have been impossible.

Dr. C. Hugh Thompson
Chief
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I. INTRODUCTION

Preceeding volumes (I-III) of this report describe in detail the development of four alternative technical approaches for the designation of harmful quantities and rates of penalty for non-removable hazardous materials as mandated in Section 311(b)(2)(B)(iv) and 311(b)(4) of the 1972 Federal Water Pollution Control Act Amendments (PL 92-500). All approaches were designed to comply with the law, but each offers unique features which vary the degree of resolution and ease of administration achieved. The mix of these two basic elements greatly affect both the acceptability of resulting regulations to various parties and the facility with which this section of the law can be administered. Similarly, each alternative is likely to have a different level of impact on potential spillers as well as the environment. It is these differences that must be characterized and considered as part of the final selection of an optimal approach.

Volume IV has been written to address these and other issues. Its two major objectives are: 1) to provide a direct comparison between alternative methodologies, and 2) to assess the economic and environmental impacts likely to result from institution of required regulations. The latter objective is accomplished first by detailing the characteristics of each approach. These are then interpreted with respect to such administrative considerations as effectiveness, equitability, ease of implementation and enforcement, and cost.

The former objective, that dealing with impacts, is discussed in terms of both differential economic effects on generic spill source types and overall impact levels on industry. Similarly, potential environmental effects are detailed both with respect to incremental effect and the estimated overall impact on the environment. The impact analyses, of necessity, deals with specific hazardous materials. Since it would be prohibitive to address all designated substances, representative chemicals from commercially important generic groups were employed.

A final section dealing with special issues related to adoption and enforcement of a regulation has been included in this volume. Of special interest here is the discussion of insurability and the response of the insurance industry to the maximum civil penalty provisions.

It is assumed that the reader has at least cursory knowledge of the technical approaches developed in the previous volumes. As a minimum, the Executive Summary (Volume I) should be read and understood prior to reviews of this analysis.

II. EXECUTIVE SUMMARY

ECONOMIC IMPACTS ON STATIONARY SPILL SOURCES

For purposes of this report, stationary spill sources included production, storage, and transfer facilities which handle hazardous materials. Substances selected for analysis in this section included the following:

- Sulfuric Acid
- Ammonia
- Methyl Parathion
- Caustic/Chlorine
- BTX (benzene-toluene-xylene)
- Phenol

These are economically important substances representative of a number of generic groups, and, with the exception of methyl parathion, are produced in large quantities at a number of locations throughout the United States. For each chemical or family of chemicals, the potential economic impacts of the penalty rates from each of the four technical approaches developed in Volume II were assessed with respect to the following items:

- Cost to the representative producer
- Size distribution of producers and potential impacts on smaller operations
- Effects on production price
- Cross production elasticity

Also discussed were the implications of the $500,000 maximum liability.

Cost to Representative Producers

For each of the materials considered, a representative size production operation was selected. Typically this operation was close to the average for the industry. Net profits for this size operation were calculated on the basis of the market price of their product and on an assumed profit margin of 6.5

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percent. Annual spillage from each operation was computed as a percentage of production. Penalty rates from each of the four methodologies were then applied to the annual spillage figure to determine the total expected fines for each operation over a one year period. Table II-1 below summarizes the results of this portion of the analysis. With the exception of chlorine* impacts of calculated fines on the representative producers were small to negligible. The figures used to compute the percentage of production spilled are considered high since they were based on reported spillage from all sources (including transportation). Computed fines are considered to be at the high end of the range for this reason, especially since many of the reported spills never reach water. Furthermore, it is likely that a portion of the annual spillage will be in small increments less than the harmful quantity; hence, no reporting (or fines) for these spills will be required.

TABLE II-1

SUMMARY OF IMPACTS ON REPRESENTATIVE PRODUCERS

MATERIAL	REPRESENTATIVE PRODUCTION UNIT	CALCULATED NET PROFIT	PERCENTAGE OF PRODUCTION SPILLED	RANGE OF[1] PENALTIES (METHODOLOGY)	PERCENTAGE OF NET PROFITS REPRESENTED BY PENALTIES
Sulfuric Acid	640 ton per day	$ 694,000	.0029	$ 468-$58,000 (RV) (DONM)	0.07 - 8.33
Ammonia	600 ton per day	$1,774,500	.0025	$ 5,985-$75,600 (UM) (DONM)	0.34 - 4.26
Caustic Soda	495 ton per day	$1,351,350	.0025	$ 160-$20,356 (RV) (DONM)	0.01 - 1.51
Chlorine	450 ton per day	$1,023,750	.0025	$38,587-$500,000 (DONM) (IMCO)	3.77 - 48.80
Benzene	59 million gal per year	$2,535,000	.0025	$ 339-$ 54,981 (UM) (DONM)	0.01 - 2.17
Phenol	200 million lbs per year	$3,510,000	.0025	$ 1,564-$ 40,377 (RV) (IMCO)	0.04 - 1.15
Methly Parathion	30 million lbs per year[2]	$ 936,000	Harmful Quantity[3]	$ 226-$ 2,475 (VM) (DONM)	0.02 - 0.26

1 RV = Resource Value Methodology
UM = Unit of Measurement Methodology

2 Only three operations presently producing methyl parathion. The 300 million pound per year operation is the middle of the three.

3 Determination of the percentage of production spilled from methyl parathion percents was not possible.

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*The physical properties of chlorine are such that a major spill into water from a stationary source is unlikely.

Size Distribution and Impacts of the Maximum Liability

Although potential impacts on representative producers were not determined to be very severe, size distribution of operations within the various industries considered in this study are such that a major spill* by some of the smaller operations could produce a severe impact when measured against profits associated with these operations. Quantifications of the likelihood of such an event was not possible. However, it is possible to depict the size distribution and expected profits of the various (under each methodology) required to incur fines equal to net profits for various size operation. Figures depicting industry size distribution for each of the chemical evaluated in this study (are contained) in Chapter III of this volume. Impacts of the $500,000 maximum liability can also be assessed. Table II-2 below shows the expected percentage reduction in net profits of the representative producer (in a single year) if this maximum liability were imposed. Also shown in this table is the percentage of operation with estimated profits less than or equal to $500,000.

TABLE II-2

POTENTIAL IMPACT OF THE MAXIMUM LIABILITY

PRODUCT	PERCENT REDUCTION IN NET PROFITS RESULTING FROM $500,000 FINE	PERCENT OF OPERATIONS WITH NET PROFITS LESS THAN OR EQUAL TO $500,000
Sulfuric Acid	72	57
Ammonia	28	18
Caustic Soda	37	41
Chlorine	49	41
Benzene	20	35
Phenol	14	0
Methyl Parathion	53	33

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*Although spillage for the representative producer was calculated as a percentage of annual production - a reflection of long term potential impacts the possibility of a large spill from one of the smaller operations could lead to severe short term impacts.

Cross Product Elasticity - Effects on Production Price

Cross product elasticity refers to the shifts or substitutions which can occur in the rise of competing materials as the prices of the materials vary. Potential liabilities associated with materials designated as hazardous and non-removable under Section 311 may necessitate price increases for the materials by manufacturers. Thus, it is necessary to consider the impacts of any price increases on the competativeness of these materials. Precise quantification of these shifts are not possible due to the probalistic nature of spill events as well as the responses of individual producers and consumers. However, it is possible to identify those materials which could experience some loss of market position as a result of potential fines. Table II-3 summarizes these potential impact and includes the price increase by the representative producer if he were to pass all costs associated with the fines calculated in Table II-1 forward.

MOBILE SPILL SOURCES

Procedures used to determine economic impacts on the transporters of hazardous materials are similar to those for stationary sources. A financial and operating profile for representative operators in each of the three major transportation modes (motor carriers, rail carriers, and barging) were derived. The representative motor carrier was derived from a sample set of 39 common carriers who had experienced a spill of one or more of the hazardous materials considered in this section. The representative rail carrier was derived from the average of the financial and operating statistics of 65 Class I railroads. The average barge carrier was derived indirectly from information on barge operating expenses in the lower Mississippi area. This approach was necessary due to the non-availability of financial and operating data for the vast majority of barging operations engaged in the transport of bulk chemicals. Table II-4 summarizes the financial and operating characteristics used in the analysis.

Potential impacts on these size operations were estimated for four designated hazardous materials (ammonia, chlorine, caustic soda, and sulfuric acid). Impacts were assessed on two spill levels -- the harmful quantity and a spill equal to the largest single bulk "container" handled by the particular mode. For the motor carriers a 30 ton tank truck was used as the largest container, for rail a 60 tank car and for barges a 1150 ton tank barge. Ranges of potential impacts on the net profile of these operations under the four penalty schedules are shown in Table II-5. As evidenced by the figures in this table, potential impacts of fines on barge operators are particularly severe.

TABLE II-3

CROSS PRODUCT ELASTICITY FOR SELECTED MATERIALS

Material	Price Increase[1] (percent change in product price)	Competing Products
Sulfuric Acid	\$0.0021-\$0.26 per ton (0.00) (0.54)	1. Sulfur dioxide and sulfur trioxide - in activities where sulfur content is of major interest (e.g.; production of surface active agents, pulping, and synthetic petroleum sulfonates). Neither of these materials are designated non-removable hazardous substances. 2. Hydrochloric Acid - in iron and steel pickling process. Hydrochloric acid is a designated non-removable hazardous material. 3. Hydrofluoric Acid - substitutable for sulfuric acid in alkylation reactions such as those employed in petroleum refining. HF is a designaged substance with penalty rates equivalent to or greater than sulfuric acid depending on the methodology used. 4. Glychol - substitutable for sulfuric acid as a dehydrating agent during manufacture of organic chemicals. Glychol is not a designated hazardous substance.

Material	Price Increase[1] (percent change in product price)	Competing Products
Sulfuric Acid (Cont'd.)		CONCLUSION: Actual impact on sulfuric acid consumption is predicted to be small because: a. substitution in major use (phosphoric acid production) is unlikely b. overall price effects of penalties are expected to be small
Ammonia	$0.03-$0.35 per ton (0.02)-(0.28)	CONCLUSION: No substitutes for ammonia in its major uses.
Caustic Soda	$0.0009-$0.12 per ton (0.00)-(0.10)	1. Soda ash (sodium carbonate) - Competition is for sodium alkali content rather than hydroxide content. CONCLUSION: Price effects estimated for caustic soda are very small, suggesting incentives for substitution are insignificant.
Chlorine	$0.25-$3.17 per ton (0.25)-(3.17)	1. Oxygen - oxygen has been a successful competitor to chlorine in pulping operation.

Material	Price Increase[1] (percent change in product price)	Competing Products
Chlorine (Cont'd.)		2. Ozone - Presently being marketed as a replacement for chlorine for disinfection purposes. CONCLUSION: Spillage of chlorine into water is expected to be significantly less than that predicted by the analysis. Despite potential high fines for the spillage of this material, significant loss of market position for this product is not expected to result from implementation of Section 311 regulations.
Benzene	~0.00-$.001 per gal (~0.00)(.14)	CONCLUSION: No substitutes for benzene in its major uses.
Phenol	$0.01-$.40 per ton (~0.00)(.07)	CONCLUSION: There are no competitive substitutes for phenol.
Methyl Parathion	$0.02-$0.17[2] per ton (~0.00)(0.02)	CONCLUSION: Competitors include other organo - phosphate pesticides which are subject to Section 311 regulation. Most pesticide plants are capable of shifting operations to produce a wide variety of formulations. Potentially service penalties for very toxic pesticides may cause some shifts in these operations.

[1] Based on fines, annual productions, and market prices shown in Table II-1

[2] Based on spillage of the harmful quantity

TABLE II-4

SUMMARY OF FINANCIAL AND OPERATING CHARACTERISTICS FOR REPRESENTATIVE MOTOR, RAIL, AND BARGE OPERATIONS

	Motor Carrier	Rail Carrier	Barge Carrier
Net Income (103 dollars)	$ 1,119	$ 6,220	$ 325
Total Operating Revenue (103 dollars)	$ 36,376	$212,854	$ 2,325
Total Expenses (103 dollars)	$ 33,956	$167,562	$ 2,000
Operating Rates (expense/revenues)	93.35	78.7	85.0

As in the analysis for stationary sources, precise determination of the operators which would be rendered marginal by the implementation of Section 311 was not possible, due primarily to the probalistic nature of spill events and the lack of sufficient historical spill data. However, it was possible to estimate the size distribution of rail and motor carriers,* and from these distribution estimates the percentage of the industry whose annual net profits are equaled to exceeded at various fine levels.

Table II-6 depicts the percentage of the industries whose net profits are equaled or exceeded at the $500,000 maximum liability level and for a spill equal to the largest container size. The reader is referred to Chapter IV for impacts at other fine levels.

ENVIRONMENTAL IMPACT

Insufficient data presently exists to quantify the environmental damage presently sustained as a result of hazardous material spills. Therefore, the impact of alternate approaches to setting harmful quantities and rate of penalty must be reviewed in a comparative manner. Some sense of the magnitude of effect can be gained by analyzing reported fish kill data and documented spills.

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*Determination of the size distribution of barge operators was not possible since financial and operating statistics for these operations will not generally be available.

TABLE II-5

RANGE OF IMPACTS OF FINES ON NET PROFITS OF MOBILE SOURCES RESULTING FROM THE SPILLAGE OF SELECTED HAZARDOUS MATERIAL INTO A RIVER

	MOTOR CARRIER		RAIL CARRIER		BARGE CARRIER	
Spilled Material	Spillage of the Harmful Quantity	Spillage of the Largest Size Container	Spillage of the Harmful Quantity	Spillage of the Largest Size Container	Spillage of the Harmful Quantity	Spillage of the Largest Size Container
Percentage Decrease in Annual Net Profits						
Anhydrous Ammonia	0.02 - 0.30 (UM) (IMCO)	2.85 - 35.81 (UM) (DONM)	0.00 - 0.06 (UM) (IMCO)	1.10 - 8.04 (UM) (IMCO)	0.09 - 1.09 (UM) (IMCO)	>100%[2]
Chlorine	0.00 - 0.38 (DONM) (IMCO)	24.68-41.70[1] (DONM)	0.00 - 0.07 (DONM) (IMCO)	0.91 - 8.04[1] (DONM)	0.02 - 1.40 (DONM) (IMCO)	>100%[2]
Caustic Soda	0.03 - 3.72 (UM) (DONM)	0.19 - 23.27 (RV) (DONM)	0.01 - 0.07 (RV) (DONM) (UM) (IMCO)	0.07 - 1.16 (RV) (IMCO)	0.11 - 17.72 (UM) (DONM)	26.35 - >100% (RV) (DONM) (IMCO)
Sulfuric Acid	0.03 - 4.42 (UM) (DONM)	0.18 - 22.27 (RV) (DONM)	0.01 - 0.08 (RV) (DONM) (UM)	0.07 - 1.16 (RV) (IMCO)	0.11 - 21.07 (UM) (DONM)	25.65 - >100% (DONM) (IMCO)

1 Level of fines reaches maximum liability for IMCO, RV, and UM methodologies.

2 Fines under all methodologies exceed annual net profits.

TABLE II-6

PERCENTAGE OF MOTOR CARRIERS AND RAIL CARRIERS WHOSE NET PROFITS ARE EQUALED OR EXCEED BY FINES FOR THE SPILLAGE OF THE LARGEST BULK CONTAINER SIZE[1]

Material	DOHM		IMCO		Resource Value		Unit Measurement		$ 500,000 Max. Liability	
	MC	RC	MC	RC	MC	RC	MC	RC	MC	RC
Ammonia	57	31	48	38	29	32	23	30	57	47
Chlorine	50	31	57	47	57	47	57	47	57	47
Caustic Acid	50	31	21	31	11	28	12	28	57	47
Sulfuric Acid	50	31	21	31	11	28	12	28	57	47

MC = Motor Carriers

RC = Rail Carriers

[1] For motor carriers a 30 ton tank truck. For rail carriers a 60 ton tank car.

In general, fish kills from various sources displayed a 257 percent increase in the number of fish effected in the decade 1960-1970. Similarly, total acreage of lakes and reservoirs increased 2,257 percent and river mile affected increased 55 percent over the same time period. Review of the Clinch River, Roanoke River, and Pond Lick spill incidents indicated that a single spill can have devastating effect on a localized ecosystem as well as interfere with basic water uses. Impact periods vary considerably with the nature of the material spilled.

Technical approaches to required regulations were determined to have an environmental impact directly associated with their propensity to accelerate reporting, and subsequent response and mitigation; and with the degree to which they will provide incentive to prevent spills. The latter point requires some assertions as to the extent of industrial response to monetary penalties. Written comments to date indicate that industry as a whole feels that public relations and cost considerations presently provide ample incentive to prevent spills. They insist that additional penalties will only provide an economic burden with no commensurate decrease in spill events.

Harmful quantities will have an impact via both the accelerated reporting and added prevention incentive. In order to compare harmful quantities resulting from alternate approaches, spill data was evaluated for sulfuric acid, caustic soda, benzene-toulene-xylene (BTX), ammonia, and phenol. It was demonstrated that use of the IMCO, Unit of Measurement, or Resource Value Methodologies would lead to reporting requirements for spills constituting greater than 99 percent of the total volume of material spilled annually. The DOHM approach was somewhat less effective because of large harmful quantities for estuarine spills. Only in the case of ammonia were additional reports required for spills representing a very small percentage of the total volume spilled.

In order to assess the relative impact of rates of penalty with respect to incentive for instituting better prevention, a composite measure of the ratio of rate of penalty/price was devised for a list of most commonly spilled materials. Results of this comparison indicate that the IMCO and DOHM approaches offer the greatest incentive for preventing spills. The combined impact of harmful quantities and rate of penalty are likely to be most favorable with the IMCO Methodology, which offers the smallest harmful quantities but high rates of penalty relative to product price.

GENERAL COMPARATIVE EVALUATION

The first section of this evaluation entailed a direct comparison of the four technical approaches. Specific aspects of the methodologies addressed in the direct comparison include:

- Specificity to waterbody type
- Specificity to waterbody size
- Specificity to chemical groups
- Ability to deal with mixtures containing more than one designated hazardous material
- Assumptions and rationale
- Severity of penalty schedule and size of harmful quantity

Table II-7 summarizes the results of the direct comparisons as well as the ranking factors assigned to each methodology under each of the six direct evaluation criteria. A ranking factor of 1 indicated that a methodology is considered to be the most desirable of the four under the particular evaluation criteria. Two numbers (e.g., 1-2 or 3-4) indicates a "tie" between two methodologies.

In the second section of the general comparative evaluation, the administrative implications of each of the four methodologies were examined to determine the relative merits of the various approaches as they affect implementation and enforcement. Direct comparison results from Table II-7 were used as the basic inputs to this analysis. From these inputs, intermediate criteria (or variables) were derived through a summation of appropriate direct comparison ratings. Methodologies were then tanked under each of the intermediate criteria. Output criteria were then derived in a similar fashion using as inputs, the direct comparison rankings and the ranked intermediate criteria. Table II-8 describes the direct intermediate, and output criteria used in this portion of the analysis. Table II-9 summarizes the relative rankings of the four methodologies under the seven output criteria.

SPECIAL ISSUES

During the course of the evaluation, it became apparent that certain special issues falling outside the context of a comparative analysis needed to be addressed. These were issues that had a bearing on any regulation developed to comply with Section 311. As such, they should be reviewed prior to selection of a technical approach. The pertinent issues fall into three categories: insurability, jurisdiction and litigation, and compliance with congressional intent.

TABLE II-7

SUMMARY OF GENERAL COMPARATIVE EVALUATION

Criteria	DOHM Methodology Rank	IMCO Methodology Rank	Resource Value Methodology Rank	Unit of Measurement Methodology Rank
A. Specificity to water body type (1 = most specific)	④ Two harmful quantity and two rate of penalty categories	② Three harmful quantity and four rate of penalty categories	① Three harmful quantity and four-plus rate of penalty categories	③ One to two harmful quantity and four rate of penalty categories
B. Specificity to water body size (1 = most specific)	② Special harmful quantities for stationary sources and barges	(3-4) None	① Extrinsic adjustment factor (Loc) for penalty rate	(3-4) None
C. Specificity to physical/chemical characteristics (1 = most specific)	① Harmful quantity and rate of penalty assigned to materials individually	(3-4) Four categories for harmful quantity and base rate of penalty. Fourteen physical/chemical groups	② Harmful quantity and base rate of penalty assigned individually. General classification used for dispersion & degradability	(3-4) Same as IMCO
D. Ability to deal with mixtures (1 = greatest ability)	(3-4) None	(1-2) Within each of four categories	(3-4) None	(1-2) Within each of four categories
E. Assumptions and rationale (1 = strongest rationale)	③ Strong handling of stream and critical volume selection. Inadequate for lakes & rivers. Poor data base for setting rates of penalty	② Good data base for rates of penalty. Weak rationale for defining threshold of harm. Persistence is underrated.	① Good data for penalty rates. Weak rationale for defining threshold of harm	④ Complies with the letter of the law. Lacks underlying technical rationale and supporting data.
F. Severity of penalty rates (1 = greatest severity)	① High for major threat materials but comparatively low for many metal salts and pesticides	② Typically higher than Resource Value except for certain metal salts and pesticides	③ Relatively low for major threat mat'l.; however, extremely high for pesticides and certain metal salts	④ Uniformly lower than IMCO except in coastal waters
G. Size of harmful quantity (1 = smallest size)	② Follows same pattern as ResV methodology differing by the ratio of critical volumes	③ Typically smaller than ResV except for certain metal salts and pesticides	④ Typically large for major threat mat'l.; however, quite small for certain pesticides and metal salts	① Typically smaller than other methodologies. Substantially smaller for coastal waters.

TABLE II-8

SUMMARY OF INPUT, INTERMEDIATE AND OUTPUT CRITERIA

Input Criteria	Intermediate Criteria (inputs)	Output Criteria (inputs)
A. Specificity to Water Body Type	1. Inducement for Preventive Action (A, B, C, D, F, G)	I. Staff and Equipment Costs (1, 2)
B. Specificity to Water Body Size	2. Ease of Technical Application (A, B, C)	II. Litigation and Negotiation Costs (4)
C. Specificity to Chemical Groups	3. Equitability of Treatment (A, B, C, D, E)	III. Ease of Administration (1, 2, 3, 4, 5)
D. Ability to Deal With Mixtures	4. Likelihood of Avoiding Legal Challenges (A, B, C, D, E, F, G)	IV. Acceptability to Industry (F, G, 3, 5)
D. Assumptions and Technical Rationale	5. Adaptability to Change (A, B, C, D, E)	V. Acceptability to Local Government (1, 3, 5)
F. Severity of Penalty		VI. Acceptability to State Government (1, 3, 5)
G. Size of Harmful Quantity		VII. Administrative Effectiveness (1, 4, 5)

TABLE II-9

SUMMARY OF OUTPUT CRITERIA

Variable Number	Output Criterion	Relative Rankings			
		DOHM	IMCO	RV	UM
I	Staff and Equipment Costs (1 = minimum costs)	1	2	4	3
II	Litigation and Negotiation Costs (1 = minimum costs)	3	2	1	4
III	Ease of Administration (1 = maximum ease of administration)	3	2	1	4
IV	Acceptability to Industry (1 = maximum acceptability)	4	2	1	3
V	Acceptability to Local Government (1 = maximum acceptability)	3	2	1	4
VI	Acceptability to State Government (1 = maximum acceptability)	3	2	1	4
VII	Administrative Effectiveness (1 = maximum effectiveness)	3	2	1	4

Insurability

The underlying problem with which this section is concerned involves determining who is going to be responsible and pay for harmful actions against society. This section examined the insurance industry and determined the extent of risks that they are willing to assume based on water pollution.

With respect to PL 92-500, a consensus of insurance underwriters indicated that coverage for water pollution will not be extended beyond $50,000 for civil penalties and $14,000,000 for clean-up costs. The consensus represents a large sample of the world-wide market. It was the feeling of the insurance industry that civil penalties are not going to reduce hazardous spills. Also, if the hazardous spill were caused by negligence, and if the civil penalty were based on negligence, the insurance industry would not take responsibility for a punitive cost due to carelessness.

Jurisdiction and Litigation

The potential for duplication and concurrent jurisdiction in the regulatory actions relating to hazardous materials spills exists between the Federal government, international conventions and state governments. Examples of potential conflicts included the Florida Water Quality Law which imposes very severe fines for oil spills as well as requiring evidence of financial responsibility above and beyond Federal requirements for transporters of oil. It was noted that similar legislation is being considered by the state of New York.

International activities beginning with the 1954 Convention for the Prevention of Pollution of the Sea by Oil may also lead to jurisdictional conflicts. The Inter-Governmental Maritime Consultative Organization (IMCO) now spearheads efforts in this area and has expanded in scope to consider hazardous materials. Recent developments include two new conventions: The Intervention Convention, and The Convention on Civil Liability for Oil Pollution Damage. The former ratified by the United States, is pertiment to oil in that it gives national governments the right to take drastic measures, even on the high seas, when the threat of dangerous pollution is imminent.

It is likely that international conventions will not lead to the complications evident from state regulations. This is due largely to the fact that international conventions must be ratified by member countries and have typically been modified to meet the desires of the participants. State regulations, however, may differ greatly from Federal ones. Indeed, when the three judge federal court in Florida struck down the

Florida statute on the grounds that it violated the principle that admiralty law should be uniform, the Supreme Court took exception. At that time, it was asserted that many of the law's provisions could be maintained including those imposing unlimited clean-up liability. The combined effect of multiple civil liabilities and varying maximum liability limits has served to overwhelm shippers and frighten off insurers.

This section also notes certain enforcement difficulties facing the regulatory agency. The bulk of these stem from the litigation aspects of assessing civil penalties and are most clearly demonstrated in a recent case in Louisiana. In *United States vs LeBouf Bros. Towing Co.*, F. Supp. (E. D. LA. 1974), the court held that civil penalties could not be assessed solely on the basis of information received in the initial report from the discharger. Rather, independently derived information was necessary to avoid claims of "self-incrimination."

Compliance of the Methodologies with Congressional Intent

Legislative intent is normally determined by a thorough reading of the applicable statute, by application of established rules of construction, and by consideration of the legislative history of the statute. The language in Section 311 of the Federal Water Pollution Control Act Amendments of 1972 leaves much discretion to the Administrator of the Environmental Protection Agency and does not make clear exactly how a methodology for determination of harmful quantities and an appropriate penalty schedule for hazardous substances should be determined. Examination of the legislative history of the Act provided some insight as to congressional intent.

The legislative history of the Act is helpful in one area because it indicates that Congress was concerned that the penalties in Section 311 might be too severe and that a preferable means of control would be regulations clearly defining requirements for safe handling and shipment of hazardous substances.

The report of the Conference Committee (PL 92-500) indicated that it was their hope that other committees of Congress would consider the need for legislation to improve hazardous materials handling, storing, and shipping procedures and that is such, legislation could be enacted then the conference agreed that the liability provisions of Section 311 should be reviewed and changed as necessary.

III. ECONOMIC IMPACT ON STATIONARY SOURCES

INTRODUCTION

This section considers the economic impacts of the penalty rates derived from the four methodologies on stationary spill sources. For purposes of this discussion, stationary spill sources include production, storage, and transfer facilities which handle hazardous materials. The Environmental Protection Agency has proposed a list[1] of well over 300 substances as being nonremovable hazardous substances under paragraph(b)(2)(B)(i), Section 311 of the 1972 Federal Water Pollution Control Act Amendments. From this list generically representative substances, used avidly throughout industry, and produced in large quantities were selected. The substances selected for analysis in this section are:

- Sulfuric acid
- Ammonia
- Methyl parathion*
- Caustic/chlorine
- BTX (Benzene-Toluene-Xylene)
- Phenol

For each chemical or family of chemicals, the potential economic impacts of the penalty rates from each of the four methodologies were assessed with respect to the following items:

- Cost to the representative producer
- Size distribution of producers and potential impacts on smaller operations
- Effects on production price
- Cross product elasticity

The general procedure followed in this section begins with a representative production unit against which each of the four penalty rates is applied assuming 1) annual spillage equal to the harmful quantity, and 2) a spillage equal to the reported (or assumed) annual percentage of production spilled by a particular industry. This approach was necessitated by the general lack of data regarding the frequency and size distribution of spills of specific materials by stationary sources into navigable waters.

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[1] Federal Register, Vol. 39, No. 164, Part IV, August 22, 1974.

*Methyl Parathion is not produced in large quantities relative to the other fine material, however, the authors believe that inclusion of a pesticide in this analysis was important.

Where applicable, the size distribution of operations engaged in the production of a given material is presented and used to estimate the potential impact on the industry as a whole. Precise determination of the marginal firm is not possible for stationary sources. Rather, the size distribution figures must be used to suggest those operations which may be rendered marginal by the various penalty schedules.

Additionally, impacts of the $500,000 maximum liability are discussed as well as the possibility of product shifts which might result from price increases required to offset potential or actual fines.

Production units for each of the chemical substances are assumed to have river locations, thus only the penalty rates associated with river spills are calculated for the examples presented in this analysis. For the DOHM and Unit of Measurement Methodologies variations in penalty rates between rivers and the three other water body types considered in this study are small. Under the IMCO and Resource Value Methodologies fines for lakes and estuaries would be close to those for river spills (within a factor of 2). Fines for spills into coastal waters would be substancially less under the latter two methodologies, typically by a factor of 40 or more.

POTENTIAL ECONOMIC EFFECTS ON SULFURIC ACID PRODUCERS

The Representative Producer

The selected representative production unit is a plant that produces 640 tons of sulfuric acid per day. The average size production unit is 700 tons per day, but this average includes the very large producer, 4800 tons per day, at Uncle Sam, Louisiana. The 640 ton per day plant produces about 224,000 tons of sulfuric acid annually (350 days per year operation). Revenues associated with sale of this output are estimated to be $10,707,200 based on a $47.80 per ton current quoted price.[2]*

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[2] Chemical Marketing Reporter, October 7, 1974.

*There is often a significant departure from the current "quoted sales price" and the price for large bulk transactions. Generally, most sales of sulfuric are made at a substantial discount from the "quoted price," reflecting, among other things, large volume purchase and costs among other things, large volume purchase and costs assignable for internally consumed production. For example, in 1972 when the quoted price for sulfuric acid was $35/ton, the average commercial shipment price was $19/ton.

A profit margin on sales of 6.5 percent has been selected to measure potential effects of various penalty schedules.* Based on this percentage, annual after tax profits for the representative firm would be about $696,000.

Cost Effects of Alternative Penalties

The representative sulfuric acid producer is assumed to spill approximately 13,000 pounds of sulfuric acid per year. This number was derived by dividing the reported spillage[3] (1.7 million pounds) of sulfuric acid by total production for the year 1971 to obtain a percentage of annual production spilled.

$$\text{Annual Percentage Spilled} = \frac{1.7 \text{ x } 10^6 \text{ lbs spilled}}{58.6 \text{ x } 10^9 \text{ lbs produced}} = 100 = 0.0029\%$$

This number is then used to derive the annual spillage for the archetypical producer as follows:

$$\text{Annual Spillage} = \frac{640 \text{ tons}}{\text{day}} \times \frac{350 \text{ day}}{\text{year}} \times (.000029) = 6.5 \text{ tons} = 13{,}000 \text{ lbs}$$

Anticipated fines for the spillage of this amount as well as for the spillage of the harmful quantity under each of the four methodologies are summarized in Table III-1. It should be noted that the 0.0029 percent figure is for total spills and therefore is somewhat high for stationary sources, since transportation related spills will also occur. Hence, use of 13,000 represents a maximum average annual spillage.

Of the four penalties, only the DOHM penalty is likely to have any significant impact. The $58,000 fine for the spillage of 13,000 pounds of sulfuric acid translates into an annual profit reduction of 8.3 percent. This calculation of the reductions in profits assumes that penalty "costs" cannot be absorbed elsewhere. Clearly the plant has a variety of options including passing costs forward to consumers and/or backward into the factors of production.

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*This is probably a bit high for sulfuric acid, but assumes that sulfuric acid sales are at least as profitable as the rest of the operations of typical integrated chemical firms (see, for example, Chemical and Engineering News, Vol. 52, No. 22, June 3, 1974.)

[3] Attaway, L. D. "Hazardous Materials Spills -- The National Problem," Proceedings of the 1972 National Conference on Control of Hazardous Material Spills, Houston, TX, March 21-23, 1972.

TABLE III-1

FINES FOR THE SPILLAGE OF SULFURIC ACID FROM A STATIONARY SOURCE INTO A RIVER

Methodology	Harmful Quantity	Penalty Rate	Fine for the Spillage of the HQ (Percent of Net Profits)	Fine for the Spillage of 13,000 lbs (Percent of Net Profits)
IMCO	7,600 lbs	$0.600/lb	$ 4,560 (0.66)	$ 7,800 (1.12)
Resource Value	17,000 lbs	$0.036/lb	$ 612 (0.09)	$ 468 (0.07)*
Unit of Measurement	5,000 lbs	$0.073/lb	$ 365 (0.05)	$ 949 (0.14)
DOHM	12,000 lbs	$4,500/lb	$54,000 (7.76)	$58.000 (8.33)

*Average spillage is less than harmful quantity, so no penalty is likely to be charged.

The Marginal Firm

In the case of stationary sources, the term "marginal firm" is perhaps a misnomer since most chemical manufacturing firms are usually engaged in the production of more than one chemical. Perhaps a better term would be the marginal operation. Under such an approach the profitability of a particular chemical manufacturing operation can be compared to the potential fines associated with the spillage of that material. Figure III-1 shows a cumulative distribution of sulfuric acid production units in the United States. Superimposed on this distribution is a scale which depicts the expected profitability of these operations under the assumptions stated at the beginning of this section. Additional scales show the amount of sulfuric acid which would have to be spilled under each of the four methodologies in order to incur fines equal to estimated profits. For example, Figure III-1 (point A) shows that seven percent of the sulfuric acid producing facilities are the 25,000 ton per year size. Estimated annual profits for this size operation are $77,675 (point B) Figure III-1. Spillage of approximately 8.6 tons of sulfuric acid under the DOHM Methodology (point D) Figure III-1 size operation. Under the Resource Value Methodology, (point C) Figure III-1, 1079 tons of product would have to be spilled.

This figure can also be used to assess the impact of the $500,000 maximum liability on sulfuric acid operation. From the figure it can be seen that 56 percent of the operations would have annual* net profits equaled or exceeded by a fine equal to the maximum liability. The lower "tons spilled" scales can be used to determine how much sulfuric acid would have to be spilled under each methodology in order to reach the maximum liability level.

Thus, in the case of stationary sources where annual spillage has been estimated as a percentage of annual production, the approach is not one of precisely defining a marginal firm (in terms of production) but rather one of profiling the industry so that potential impacts on the smaller size operations can be accurately assessed.

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*The reader is reminded that it is considered extremely unlikely that any given operation would experience spills of the magnitude required to reach the maximum liability level year after year. Thus, the figure alone represents a situation that could occur in "any given year," and does not imply that 56 percent of the sulfuric acid industry would be bankrupted by spills at the maximum liability level.

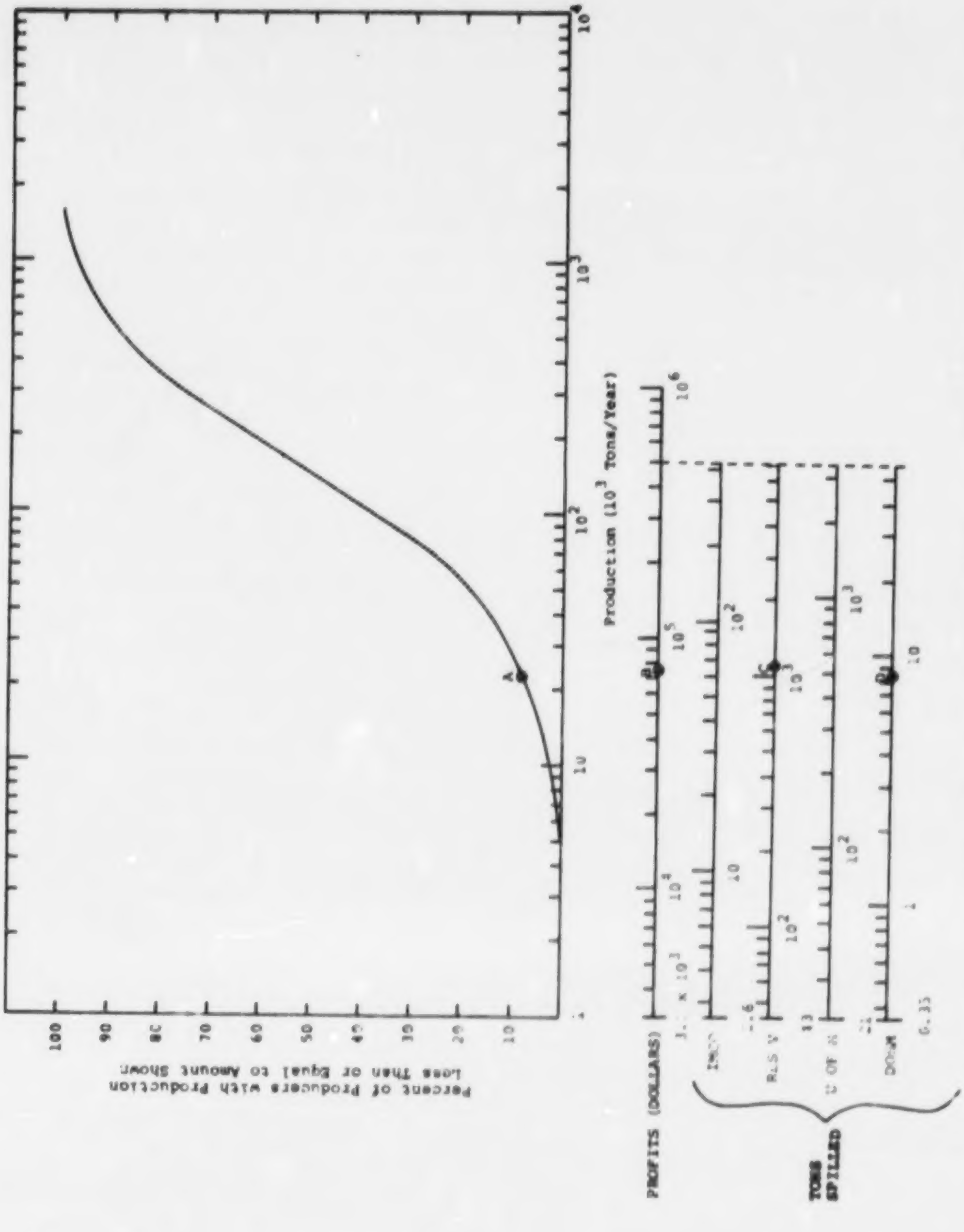

FIGURE III-1. CUMULATIVE DISTRIBUTION OF SULFURIC ACID PRODUCERS[4]

Price Effects of Alternative Penalties

For the representative firm, a price pass-through of $0.26/ton would be required to offset fines resulting from the spillage of 13,000 pounds under the DOHM Methodology (highest fines). As the quoted price of $47.80/ton, this represents a price increase of 0.54 percent.

Impacts on the prices of other products produced from sulfuric acid can be estimated by passing the assumed price increases along through various product chains. A typical product chain for sulfuric acid is illustrated in Figure III-2. Consider, for example, the production of phosphatic fertilizer the major use of sulfuric acid. Assume that this 0.54 percent price pass-through is effected by the sulfuric acid producer to cover anticipated fines. This price increase applied to phosphoric acid production would increase phosphoric acid prices (assuming phosphoric acid producers also pass the price increase along) by about 0.82 percent. That is to say:

- 2.5 tons of sulfuric acid are required to produce one ton of phosphoric acid,
- at $0.26 per ton increased price of sulfuric acid, $0.65 is the increased cost of the amount of sulfuric acid required to produce one ton of phosphoric acid, and
- at $79.44 total cost per ton of phosphoric acid, $0.65 represents a 0.82 percent price increase.[5]

At the next production stage, production of diammonium phosphate, passing along the higher phosphoric acid price, results in an increased fertilizer price of about 1.29 percent, i.e.,

- 1.175 of phosphoric acid are required to produce one ton of diammonium phosphate,
- at $0.65 per ton increased price of phosphoric acid, $0.76 is the total increased cost of the amount of phosphoric acid required to produce one ton of fertilizer, and
- at $59.03 total cost per ton of diammonium phosphate, $0.76 represents a 1.29 percent price increase.[5]

From Table III-2 it can be seen that phosphatic fertilizers comprise an estimated 11.7 percent of variable costs in crop production. However, these variable costs translate into only

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[5] "Phosphatic Fertilizers, Properties and Processes," Sulfur Institute, Washington, DC, 1974.

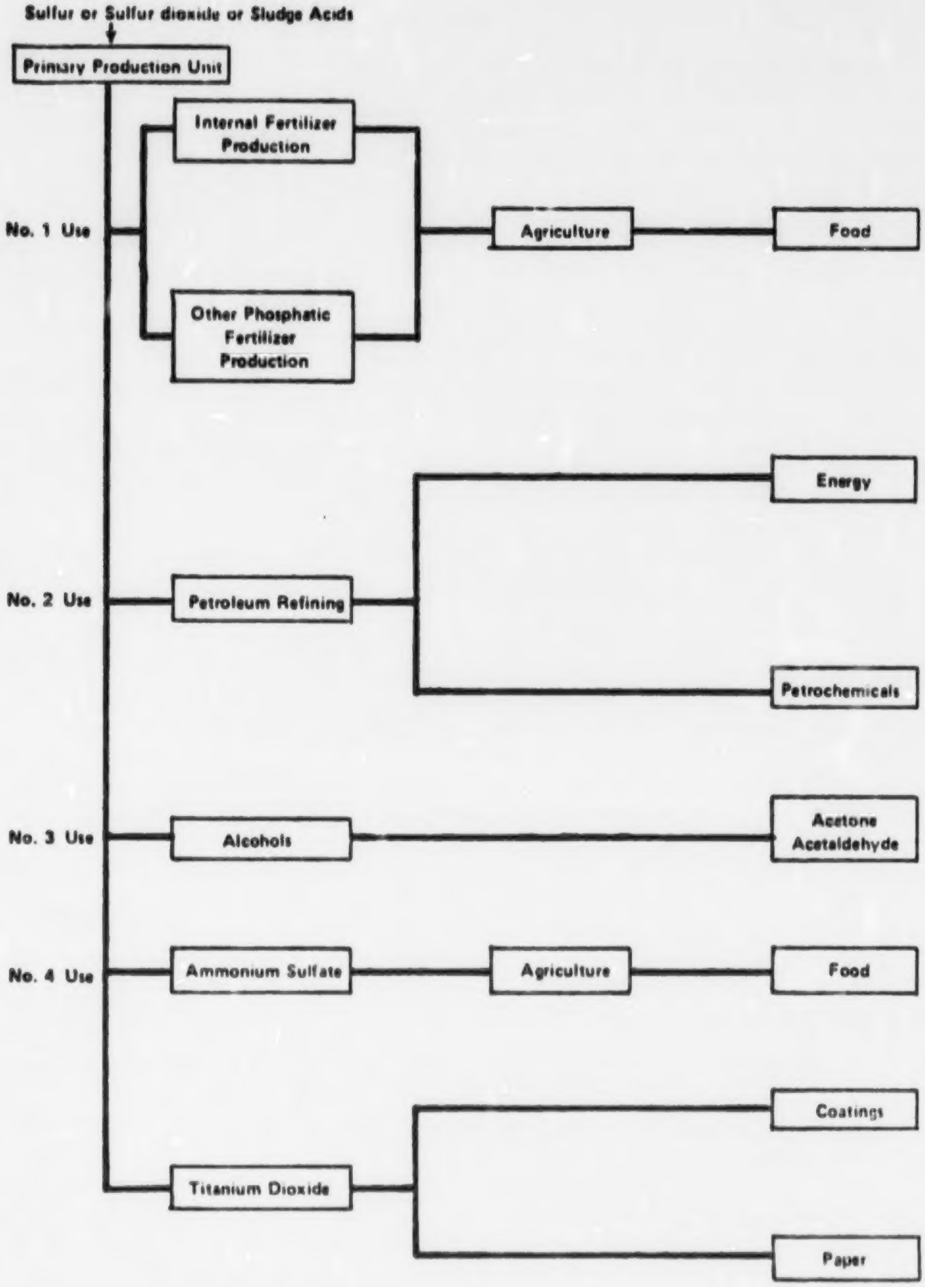
Sulfur or Sulfur dioxide or Sludge Acids
Primary Production Unit
No. 1 Use
Internal Fertilizer Production
Other Phosphatic Fertilizer Production
Agriculture
Food
No. 2 Use
Petroleum Refining
Energy
Petrochemicals
No. 3 Use
Alcohols
Acetone Acetaldehyde
No. 4 Use
Ammonium Sulfate
Agriculture
Food
Titanium Dioxide
Coatings
Paper

FIGURE III-2. PRODUCT CHAIN FOR SULFURIC ACID

TABLE III-2

ANALYSIS OF PASSTHROUGH OF PHOSPHATIC FERTILIZER COSTS

Crop	Average Price Per Bushel[1]	Average Yield Per Acre[2]	Price of Phosphorus - Average Quantity Used Per Acre (Based on Crop)	Average Variable Cost Per Acre	Percent of Variable Costs Attributed to Usage of Phosphorus Fertilizers	Average Variable Cost Per Acre Measured at Market Prices (Percent)	Percent of Market Price Based on Usage of Phosphorus Fertilizers
Corn for Grain	$1.26	$108.34	$4.84	$40.73	11.9	34.4	4.5
Wheat	$1.53	$ 54.03	$4.43	$28.83	18.6	44.1	8.2
Soybeans	$4.16	$113.50	$0.50	$22.03	2.3	19.4	4.5
Oats	$0.75	$ 41.60	$2.14	$15.24	14.0	36.6	5.1
Average					11.7		

Source:

This analysis is based on data from six major agricultural producing areas. The areas are: Southern Minnesota, Western Iowa, Northwestern Missouri, West Central Illinois, Southern Indiana, and Northwestern Ohio.

[1] Average price per bushel is based on the agricultural prices reported by the Department of Agriculture, 6/73, for each growing area.

[2] Average yield per acre is bushels per acre multiplied times market price of specific crop taken from 1973 price index for each region.

a 5.6 percent of the market price of agricultural production. With farmers spending an estimated 5.6 percent of total production costs on phosphatic fertilizers to produce agricultural products, the 1.29 percent price increase of the fertilizer translates into a market price increase for the crops of 0.07 percent.

Maximum Liability

In the event of the imposition of the maximum fine of $500,000, the representative producer with calculated annual net profits of $696,000 would experience a profit reduction of 72 percent. The quantities of sulfuric acid which would have to be spilled to reach the $500,000 maximum liability are shown in Table III-3 below.

TABLE III-3

QUANTITY OF SULFURIC ACID SPILLED
TO REACH MAXIMUM LIABILITY

Methodology	Quantity Spilled
IMCO	417 tons
Resource Value	6945 tons
Unit of Measurement	3425 tons
DOHM	56 tons

Spills into water of this magnitude from a stationary source, with the possible exception of the DOHM figure of 56 tons, are considered rare events especially if spill prevention measures are in effect. Data on sulfuric acid spills collected for a recently completed Environmental Protection Agency study[6] indicates that approximately 10 percent of the reported sulfuric acid spills are of this size or greater (see Chapter V for details on spill size distribution).

For the representative firm, this fine translates into a price increase of $2.23 per ton -- a 4.67 percent increase. Using the same procedure as before, this price translates into an 11 percent increase in diammonium phosphate and a 0.61 percent average increase in market price of crops.

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[6] Buckly, J. L. and S. A. Weiner. Data collected during performance of Contract No. 68-03-0317, "Historical Documentation of Hazardous Material Spills," Transmitted November 1974.

Cross-Product Elasticity

Whereas many materials may be substituted for sulfuric acid to achieve acidity, the major uses for sulfuric acid are based on the sulfur content. This minimizes substitution considerably. The areas where competition is a real concern include:[7]

- In activities where the sulfur content is of major interest, such as pulping and the production of surface active agents and synthetic petroleum sulfonates; sulfur dioxide and sulfur trioxide are presenting increased competition. Neither of these materials are designated hazardous substances, and hence both will become increasingly attractive if proposed spill penalties lead to subsequent price increases for sulfuric acid.

- Iron and steel pickling processes may not be designed around the use of hydrochloric acid based on new technology. The proposed penalties will most likely encourage this shift if they have any effect since rates of penalty for all methodologies are relatively the same, but hydrochloric acid offers more acidity per pound of chemical than sulfuric acid. The difference is slight, however, and not likely to be a major factor.

- Hydrofluoric acid can be substituted for sulfuric acid in alkylation reactions such as those employed in petroleum refining. Hydrofluoric acid is a designated hazardous substance with rates of penalty similar to, in the case of the DOHM Methodology, or up to five times as large as those for sulfuric acid. Like hydrochloric acid, hydrofluoric acid offers more acidity per pound but not five times as much. Therefore, while the DOHM Methodology may encourage hydrofluoric substitution, the Resource Value Methodology would discourage it.

- Glycol can be used as a dehydrating agent in place of sulfuric acid during the manufacture of organic chemicals. Since glycol is not a designated hazardous substance, this substitution would be encouraged by institution of any rate of penalty regulation.

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[7] Little, A. D., Inc. "A Modal Economic and Safety Analysis of the Transportation of Hazardous Substances in Bulk," Contract No. C-76-446, U. S. Maritime Administration, May 1974.

While the majority of these uses for sulfuric acid show a trend to higher substitution if penalties are enforced, the actual impact on sulfuric acid production is predicted to be small for two reasons: 1) substitution is not likely in the major use of sulfuric acid-phosphoric acid production for phosphate fertilizers, and 2) overall price effects of penalties on sulfuric acid are predicted to be quite small.

POTENTIAL ECONOMIC EFFECTS ON AMMONIA PRODUCERS

The Representative Producer

For ammonia a 600 ton per day plant has been selected as the representative production unit. This size plant is close to the average for the industry. The 600 ton per day facility produces about 210,000 tons per year annually (350 days per year operation). Revenues associated with the sale of this output are $27.3 million, based on a $130 per short ton sales figure.* For the $27.3 million in sales, annual after tax profits at 6.5 percent of sales would be about $1,774,500.

Cost Effects of Alternative Penalties

For the representative ammonia producer, it is assumed that an average of 0.0025** percent of annual production is spilled. At this level, 5.25 tons (10,500 pounds) per year would be spilled. Fines which would result from the spillage of this amount as well as the harmful quantity under the four methodologies are summarized in Table III-4.

Of the four methodologies, only the IMCO and DOHM are likely to have significant impacts. For the IMCO Methodology annual spillage of 5.25 tons translates into fines equal to 2.78 percent of profits; for the DOHM Methodology 4.26 percent of profits. This reduction in profits is calculated assuming that penalty costs are not passed forward or backward.

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*The October 1974 quoted wholesale price for ammonia delivered east of the Rockies was $130 -- $155 subtracting freight costs of $5 -- $10, a figure of $130 is used for calculating revenues. As with sulfuric acid, large commercial shipments are transacted at prices substantially lower than the quoted price.

**The percentage of production spilled annually is an assumed number based on the average of 0.0029 percent for sulfuric acid,[3] 0.0025 percent for phenol[3] and 0.002 percent estimated for oil in general. Once again, this is a maximum annual figure since some of the 0.0025 percent is actually spilled during transport when the shipper may not be responsible.

TABLE III-4

FINES RESULTING FROM THE SPILLAGE OF ANHYDROUS AMMONIA FROM A STATIONARY SOURCE INTO A RIVER

Methodology	Harmful Quantity	Penalty Rate	Fine for the Spillage of the Harmful Quantity (Percent of Net Profit)	Fine for the Spillage of 5.25 Tons (Percent of Net Profit)
IMCO	760 lbs	$4.70/lbs	$3,572 (.20)	$49,350 (2.78)
Resource Value	460 lbs	$1.10/lbs	$ 506 (.03)	$11,550 (0.65)
Unit of Measurement	500 lbs	$0.57/lbs	$ 285 (.02)	$ 5,985 (0.34)
DOHM	330 lbs	$7.20/lbs	$2,376 (.13)	$75,600 (4.26)

The Marginal Firm

As in the case of sulfuric acid, the analysis of the marginal firm is in essence an evaluation of the size and profitability of an operation in light of potential fines which may result from a spill. Figure III-3 shows a cumulative distribution of ammonia production units in the United States. Superimposed on this distribution is a scale depicting the profitability of these operations under the assumption (e.g., financial and operating characteristics) stated at the beginning of this section. Additional scales show the amount of ammonia that would have to be spilled under each of the four methodologies in order to incur fines equal to estimated profits. Inspection of Figure III-3 reveals that approximately 10 percent of the ammonia production units are in the 35 thousand ton per year or smaller category. Under the highest penalty rate schedule (DOHM), a spill size of 20.5 tons would be required to incur fines equal to the estimated profits of these size operations. Operations with production capacities in excess of 59 thousand tons per year (∿21 percent) would have annual profits in excess of the $500,000 maximum liability.

Price Effects of Alternative Penalties

For the representative firm a price pass-through of $0.35 per ton would be required to offset penalties anticipated from the spillage of 5.25 tons per year under the DOHM (high) penalty schedule. Under the Unit of Measurement Methodology (low) a price pass-through of approximately $0.03 would be required. These would equate respectively to a 0.3 and 0.02 percent increase in the quoted price of anhydrous ammonia. Such price increases are considered insignificant. The product chain for ammonia is presented in Figure III-4.

Maximum Liability

The effects of the maximum liability of $500,000 on the representative operation are substantial. Imposition of such a fine would result in a 28 percent reduction in profits -- as noted previously firms with annual production less than 59 thousand tons per year would have profits less than the $500,000 fine. To offset the $500,000 fine, the representative producer would have to raise prices $2.38/ton or about 1.83 percent. This price increase assumes that the producer would be incurring this fine annually -- a rather improbable situation.

The quantities of ammonia which would ahve to be spilled to incur maximum penalty under each of the four methodologies is shown in Table III-5.

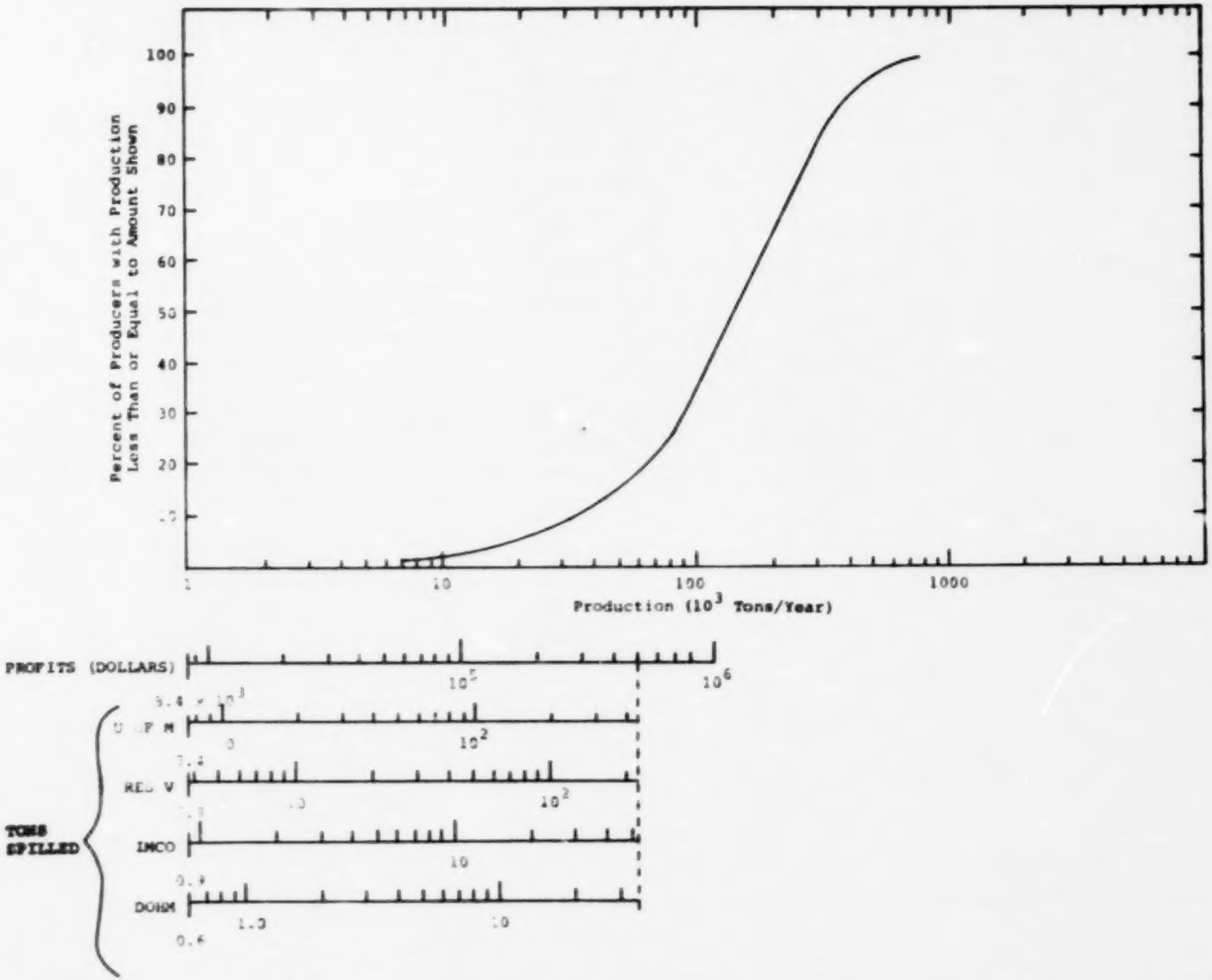

FIGURE III-3. CUMULATIVE DISTRIBUTION OF ANHYDROUS AMMONIA PRODUCERS[4]

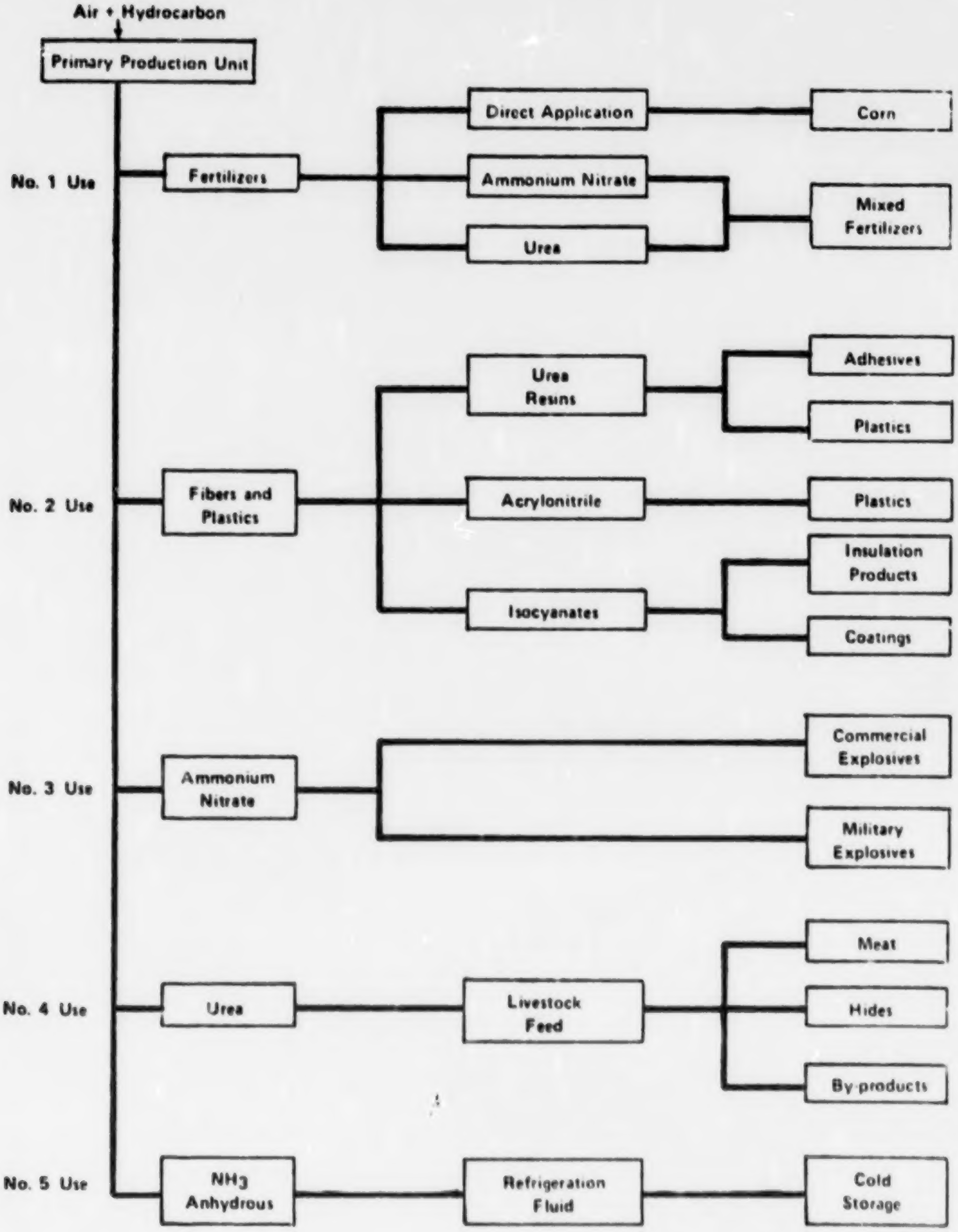
Air + Hydrocarbon
Primary Production Unit
No. 1 Use
Fertilizers
Direct Application
Corn
Ammonium Nitrate
Mixed Fertilizers
Urea
No. 2 Use
Fibers and Plastics
Urea Resins
Adhesives
Plastics
Acrylonitrile
Plastics
Insulation Products
Isocyanates
Coatings
No. 3 Use
Ammonium Nitrate
Commercial Explosives
Military Explosives
No. 4 Use
Urea
Livestock Feed
Meat
Hides
By-products
No. 5 Use
NH3 Anhydrous
Refrigeration Fluid
Cold Storage

FIGURE III-4. PRODUCT CHAIN FOR AMMONIA

TABLE III-5

QUANTITY OF AMMONIA SPILLED TO REACH MAXIMUM LIABILITY

Methodology	Quantity Spilled
IMCO	53.2 tons
Resource Value	227.2 tons
Unit of Measurement	438.6 tons
DOHM	34.7 tons

With the exception of the IMCO and DOHM quantities, spills of this size from a single facility are considered unlikely. Data from a previous study[6] indicates that 38 percent of reported ammonia spills are 35 tons or greater.* The same study indicates that less than 20 percent of reported ammonia spills are larger than 220 tons.

Cross-Product Elasticity

There are no substitutes available for ammonia in its major uses.[7] Consequently, price effects will likely be absorbed with no shift in use patterns.

POTENTIAL ECONOMIC EFFECTS ON CAUSTIC/CHLORINE PRODUCERS

The Representative Producer

A 495 ton per day caustic/450 ton per day chlorine plant has been selected as the representative production unit. The process is assumed to be a electrolysis of brine operation which yields a strict 1.1:1 ratio of caustic soda to chlorine. The representative producer compares favorably with U. S. average size plants, which includes all procedures using all processes. For the U. S., the average chlorine production unit is 440 tons per day, and the average caustic production unit is 493 tons per day.[8]

The representative operation produces 173,250 and 157,500 tons of caustic and chlorine respectively per year (350 days per year operation). Revenues associated with sale of these co-products are $20.79 million for caustic based on $120/ton[2] for 50 percent liquid, 76 percent Na_2O (76 percent Na_2O = 98.390 NaOH) with freight equalized. Revenues for chlorine are estimated at $15.75 million based on $100/ton^2 liquid with freight equalized.

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*Calculations assume spillage is 2870 solution.

[8] Current Industrial Reports, Inorganic Chemicals, Series N28A, Bureau of Budget, 1972.

Applying the 6.5 percent profit margin on sales, annual after tax profits are $1,351,350 for caustic and $1,023,750 for chlorine.

Cost Effects of Alternative Penalties

As with ammonia an average figure of 0.0025 percent of production spilled is used for caustic and chlorine. For caustic this results in an annual spillage of 4.33 tons from the archetypical production unit. For chlorine the annual spillage is estimated at 3.94 tons.* Tables III-6 and III-7 summarize expected fines for these two materials.

Cost effects resulting from the spillage of caustic soda are negligible under all methodologies except the DOHM Methodology. Expected annual spillage is actually less than the harmful quantity for the Resource Value and DOHM Methodologies. Even under the DOHM Methodology expected decrease in net profits is less than 2 percent with the spillage of the harmful quantity. Penalties resulting from the IMCO and Resource Value Methodology for the spillage of chlorine are substantial.

The Marginal Firm

Caustic Soda

Figure III-5 shows the cumulative distribution of caustic soda production units in the United States. Approximately 20 percent of these units are of the 25 thousand tons per year (or smaller) size with many of the units in this range associated with pulp mill operations. Under all methodologies except the DOHM Methodology, even these smaller operations would have to experience very large spills in order to incur fines equal to net profits. Under the DOHM Methodology a spill of 20.7 tons would be required to eliminate annual profits for a 25 thousand ton per year operation.

Chlorine

Penalty rates under all methodologies for the spillage of chlorine are high (Figure III-6). For this material the marginal operations might well be those which could not sustain the $500,000 maximum

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*It is quite likely that spillage of chlorine is much less than 0.0025 percent of production due to the more rigorous material specifications and operating procedures associated with the production, handling, and storage of chlorine.

TABLE III-6

FINES RESULTING FROM THE SPILLAGE OF CAUSTIC SODA* FROM A STATIONARY SOURCE INTO A RIVER

Methodology	Harmful Quantity	Rate of Penalty	Fine for Spillage of Harmful Quantity (% Reduction in Profits)	Fine For Spillage of 4.33 Tons (% Reduction in Profits)
IMCO	7,600 lbs	$0.600/lbs	$ 2,280 (0.17)	$ 2,599 (0.19)
Resource Value	13,000 lbs	$0.037/lbs	$ 240 (0.02)	$ 160 (0.01)
Unit of Measurement	5,000 lbs	$0.073/lbs	$ 182 (0.01)	$ 316 (0.02)
DOHM	9,600 lbs	$4.70/lbs	$22,560 (1.67)	$20,356 (1.51)

---

*Calculations based on 50% solution.

TABLE III-7

FINES RESULTING FROM THE SPILLAGE OF CHLORINE FROM A STATIONARY SOURCE INTO A RIVER

Methodology	Harmful Quantity	Rate of Penalty	Fine for Spillage of Harmful Quantity (Percent Reduction in Profits)	Fine for Spillage of 3.94 Tons (Percent Reduction in Profits)
IMCO	69.0 lbs	$66.00/lbs	$4,554 (.44)	$500,000 (48.80)
Resource Value	14.0 lbs	$37.00/lbs	$ 518 (.05)	$291,375 (28.50)
Unit of Measurement	50.0 lbs	$ 8.40/lbs	$ 420 (.04)	$ 66,150 (6.46)
DOHM	9.7 lbs	$ 4.90/lbs	$ 48 (.00)	$ 38,587 (3.77)

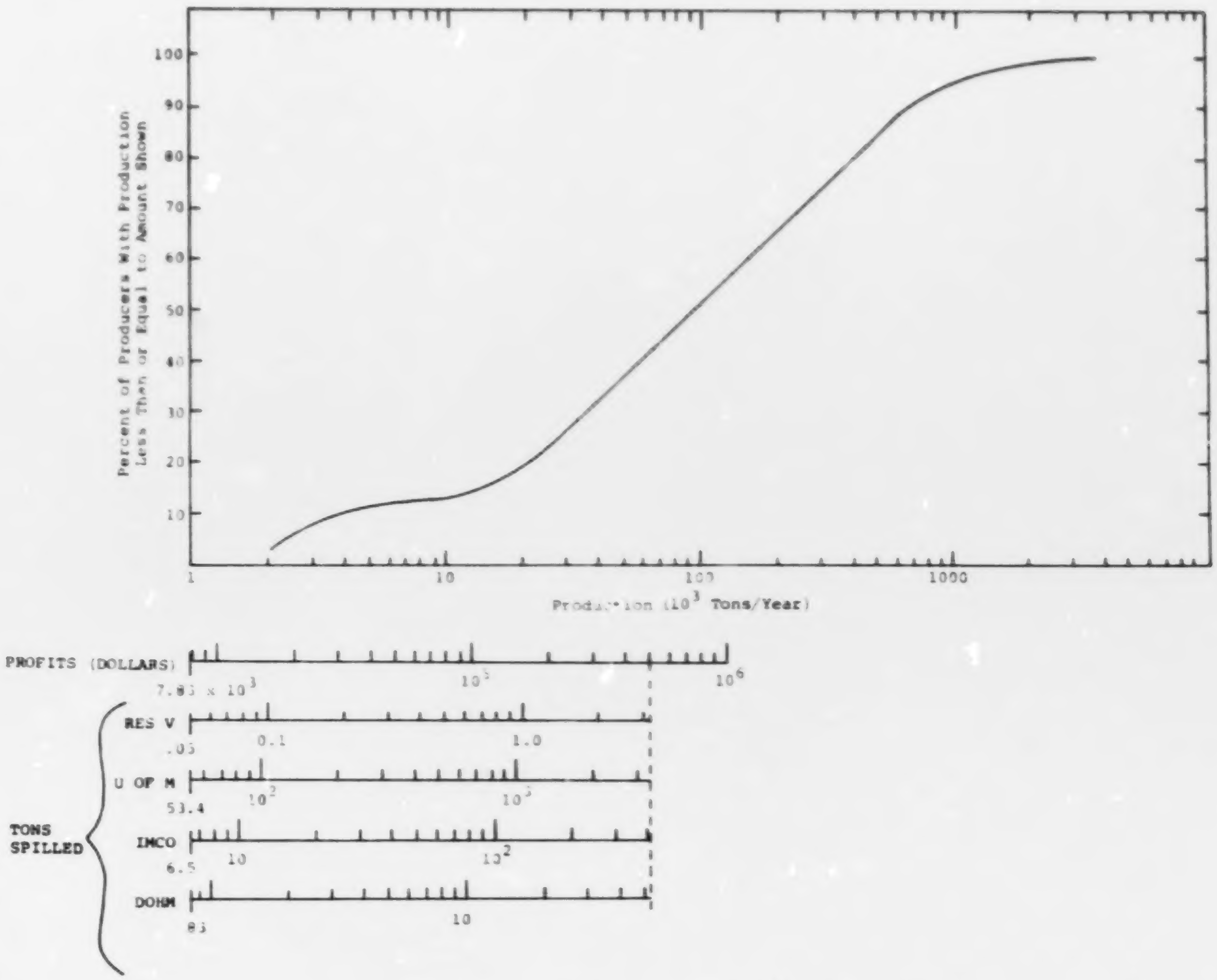

FIGURE III-5. CUMULATIVE DISTRIBUTION OF CAUSTIC SODA PRODUCERS[4]

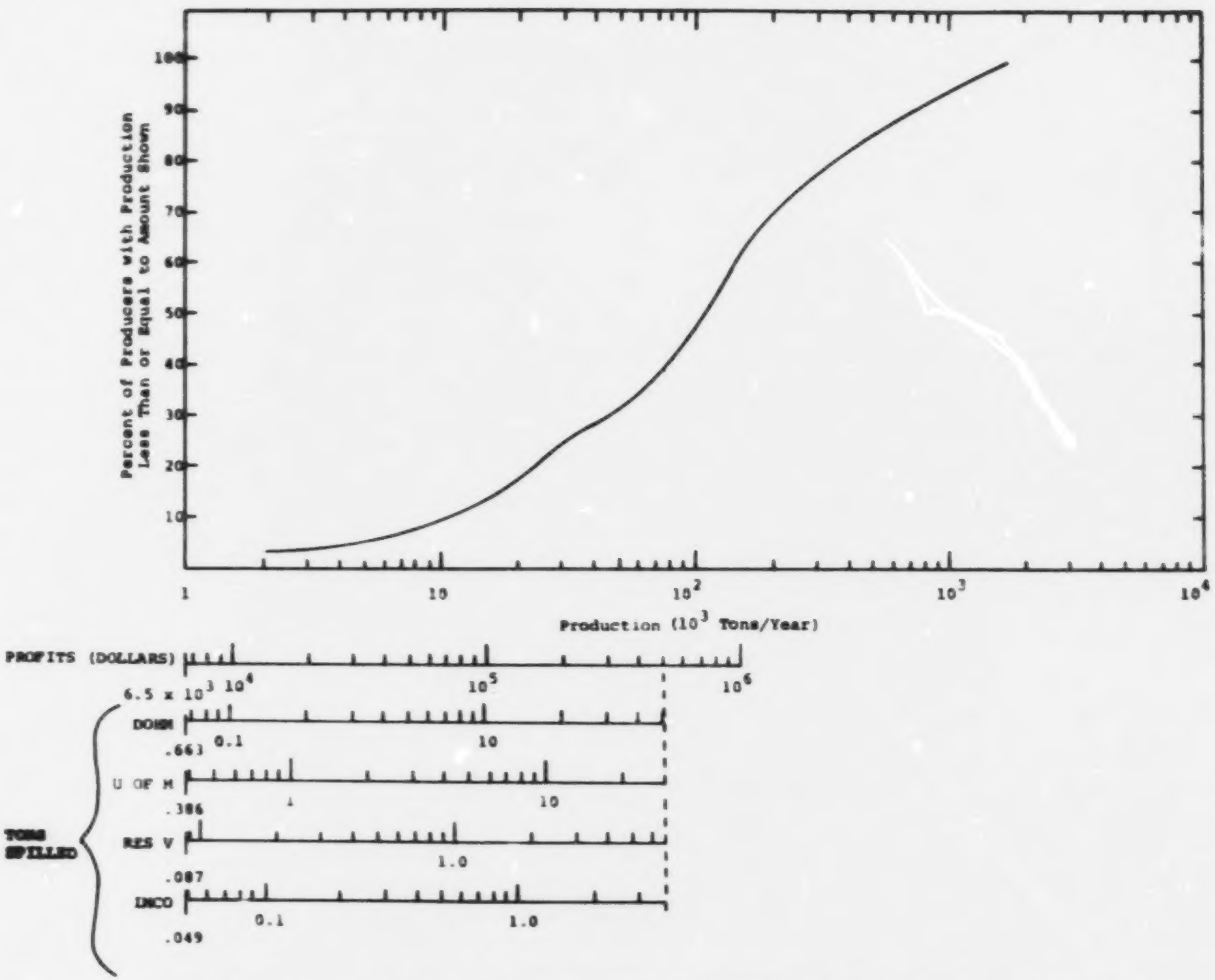

FIGURE III-6. CUMULATIVE DISTRIBUTION OF CHLORINE PRODUCERS[4]

liability. For example, under the IMCO Methodology (highest penalty rate) only 3.79 tons of chlorine need be spilled into water in order to reach the maximum liability level. There are, however, a number of inherent factors associated with the production of chlorine which would tend to mitigate the amount of this material that would be spilled or reach water when spilled. Material specifications for the equipment used in the production of chlorine are typically more stringent than those associated with the manufacture of many other industrial chemicals. This is a direct result of the toxic properties of this material. For the same reason, operating procedures and safety precautions associated with the handling and storage of this material are tight. Both of these factors should work to minimize the spillage of chlorine. Furthermore, if and when a large quantity of chlorine is inadvertently released, it is likely the major portion of this release will be to the atmosphere -- that is, the only situation in which large quantities of chlorine could be transported from a stationary source to a nearby watercourse is one whereby the chlorine is dissolved in a medium which will flow to the watercourse. Thus, although the potential fines for the spillage of chlorine are high, the stationary source, due to its inherent properties, is less likely to experience a major spill of chlorine into a waterbody.

Price Effects of Alternative Penalties

Caustic Soda

For the representative production unit, a price pass-through of $0.12 (0.1 percent) per ton would be required to offset expected annual fines under the DOHM Methodology (highest fine). This pass-through is considered insignificant.

Chlorine

Due to the high penalty rates, the price pass-through to compensate for the spillage of chlorine from the representative production unit is conservatively estimated on the basis of the $500,000 maximum liability.* Such an approach would result in a $3.17 per ton (3.17 percent) increase in the price of chlorine. Such an estimate is a worst case assessment. Actual price increases (if any) would fall somewhere below this level.

Production chains for caustic soda and chlorine are presented in Figures III-7 and III-8.

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*Note from Table III-7, this level was reached only under the IMCO Methodology.

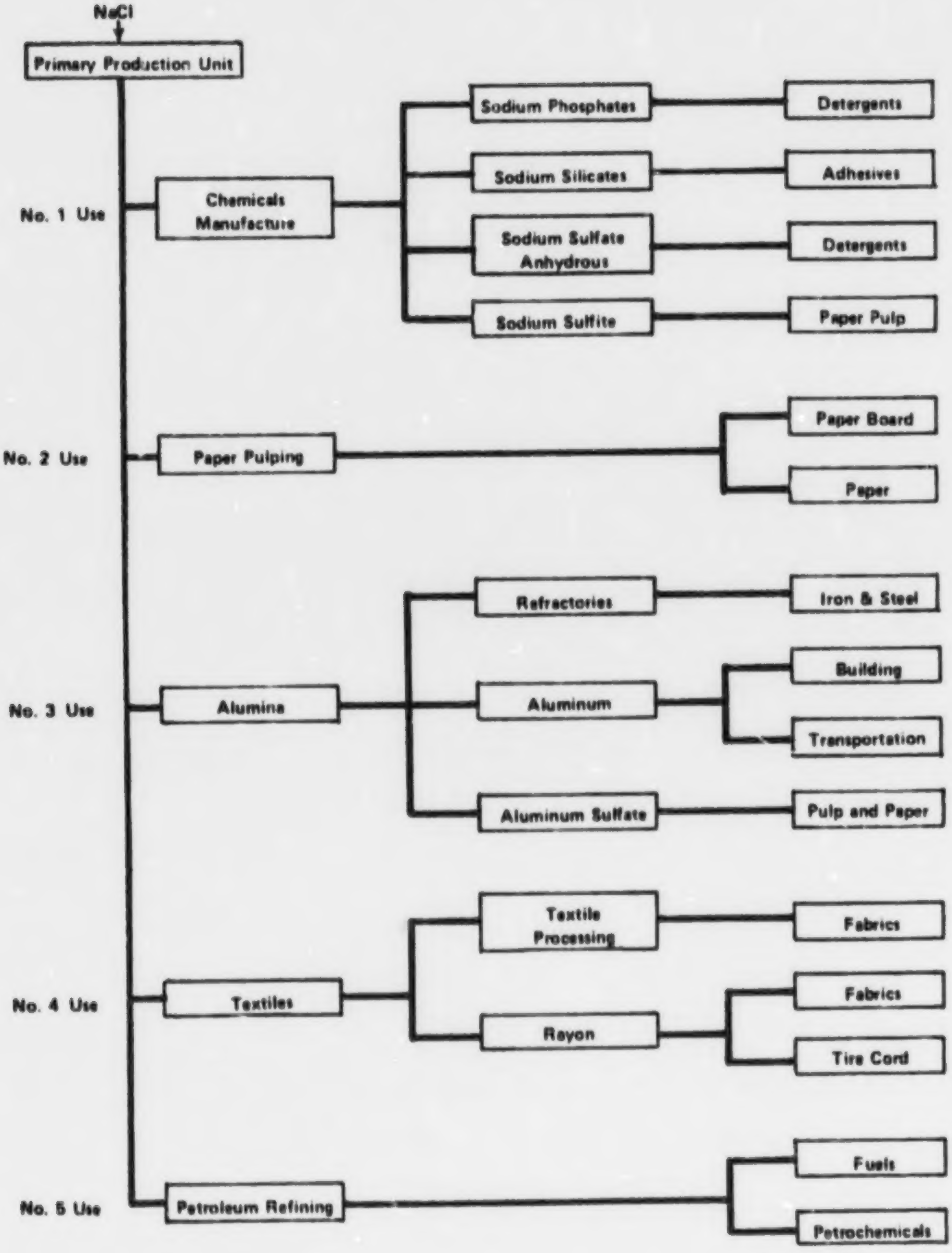
NaCl
Primary Production Unit
No. 1 Use
Chemicals Manufacture
Sodium Phosphates
Detergents
Sodium Silicates
Adhesives
Sodium Sulfate Anhydrous
Detergents
Sodium Sulfite
Paper Pulp
No. 2 Use
Paper Pulping
Paper Board
Paper
No. 3 Use
Alumina
Refractories
Iron & Steel
Aluminum
Building
Transportation
Aluminum Sulfate
Pulp and Paper
No. 4 Use
Textiles
Textile Processing
Fabrics
Rayon
Fabrics
Tire Cord
No. 5 Use
Petroleum Refining
Fuels
Petrochemicals

FIGURE III-7. PRODUCT CHAIN FOR CAUSTIC SODA

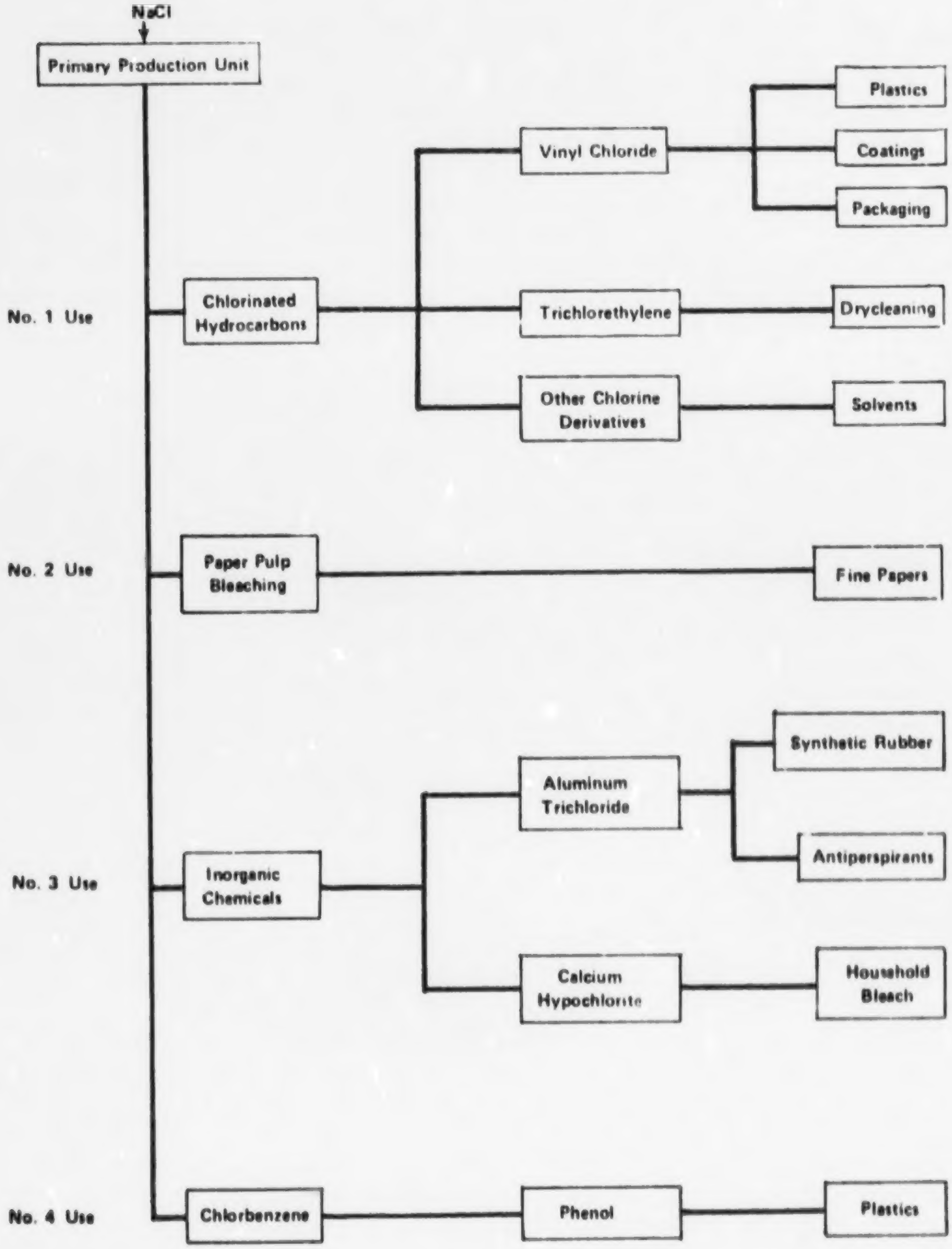
NaCl
Primary Production Unit
No. 1 Use
Chlorinated Hydrocarbons
Vinyl Chloride
Plastics
Coatings
Packaging
Trichlorethylene
Drycleaning
Other Chlorine Derivatives
Solvents
No. 2 Use
Paper Pulp Bleaching
Fine Papers
No. 3 Use
Inorganic Chemicals
Aluminum Trichloride
Synthetic Rubber
Antiperspirants
Calcium Hypochlorite
Household Bleach
No. 4 Use
Chlorbenzene
Phenol
Plastics

FIGURE III-8. PRODUCT CHAIN FOR CHLORINE

Maximum Fine

Imposition of the $500,000 maximum penalty would result in a 37 percent reduction in profits to the representative caustic operation and a 49 percent reduction in profits to the representative chlorine operation. The quantities of these two materials, which would have to be spilled to reach this level, are summarized in Table III-8 below.

TABLE III-8

QUANTITY OF CAUSTIC SODA AND CHLORINE SPILLED TO REACH MAXIMUM LIABILITY

Methodology	Quantity Spilled (Caustic/Chlorine)
IMCO	833/ 3.8 tons
Resource Value	13,513/ 6.8 tons
Unit of Measurement	6,849/29.8 tons
DOHM	106/51.0 tons

For caustic soda, spills of this size from a stationary source are considered unlikely especially if spill prevention measures are in effect. Results of the Factory Mutual Research[6] study indicate that approximately 10 percent of the reported caustic soda* spills were greater than 106 tons -- the amount required to reach the maximum liability level under the DOHM approach. Although the sizes of chlorine spills required to reach maximum liability are substantially smaller, it is still considered unlikely that even these quantities would reach water.

Cross-Product Elasticities

Caustic Soda

Most caustic soda is employed for the sodium alkali content rather than its hydroxide content. Consequently, soda ash -- sodium carbonate -- is the prime bulk chemical competitor.[7] Soda ash is not a designated hazardous substance and, therefore, its use may be encouraged by institution of rates of penalty. However, the price effects estimated for caustic soda are very small, suggesting that the additional incentive for substitution may be insignificant.

---

*Assuming as 7570 solution.

Chlorine

Substitutes have sought to replace chlorine in many of its present uses. Oxygen has been a successful competitor in pulping processes.[7] This trend is likely to be enhanced by institution of rates of penalty since price effects for chlorine can be significant. Ozone, another non-designated material, is being marketed as a replacement for chlorine for disinfection purposes.[7] The price differential is quite high, however, and will not be reversed by the rates of penalty developed here.

Price effects on chlorine are likely to be carried through to hydrochloric acid. This would upset any substitution for sulfuric acid uses otherwise predicted strictly from comparison of rates of penalty.

POTENTIAL ECONOMIC EFFECTS ON BENZENE PRODUCERS

The Representative Producer

Of the BTX family, benzene has been selected to illustrate the effects of spill penalties. A 50 million gallon per year (470 tons per day) light oil reformer production unit has been set up as the representative. The average size unit for 60 smaller plants is 30 million gallons per year, but reflects 16 smaller plants that produce only a small proportion of total output. The size distribution for all production units ranges from 200,000 gallons per year to 185 million gallons per year. Total 1973 production was 1,419 million gallons per year. Total 1973 production was 1,419 million gallons while capacity was 1,767 million gallons.[9] More than half of total production is produced by the light oil reformer process.

Annual revenues for the archetypical plant are estimated at $39 million, based on a $0.78 per gallon sales price[2] for nitration grade with freight equalized. Applying the 6.5 percent profit margin on sales, annual after tax profits would be about $2,535,000.

Cost Effects of Alternative Penalties

Spillage from the representative benzene operation is calculated to be 1250 gallons per year (4.58 tons), once again assuming that 0.0025 percent ofproduction is spilled.[3] Anticipated fines for the spillage of this amount as well as the harmful quantity are shown in Table III-9.

---

[9] *Chemical and Engineering News*, January 1, 1974.

TABLE III-9

FINES FOR THE SPILLAGE OF BENZENE FROM A STATIONARY SOURCE INTO A RIVER

Methodology	Harmful Quantity	Rate of Penalty	Fine for the Spillage of a Harmful Quantity (Percent of Net Profits)	Fine for the Spillage of 4.58 Tons (Percent of Net Profits)
IMCO	7,600 lbs	$0.270/lbs	$ 2,052 (.08)	$ 2,474 (0.10)
Resource Value	4,200 lbs	$0.048/lbs	$ 202 (.01)	$ 404 (0.02)
Unit of Measurement	4,032 lbs	$0.037/lbs	$ 149 (.01)	$ 339 (0.01)
DOHM	3,000 lbs	$6.000/lbs	$18,000 (.71)	$54,981 (2.17)

Of the four penalty schedules, only the DOHM penalty is likely to have any impact. The $54,981 fine for the estimated annual spillage of 4.58 tons translates into an annual profit reduction of 2.17 percent. As with the other materials discussed in this chapter, this reduction is based on the assumption that penalty "costs" are not absorbed elsewhere.

The Marginal Firm

Figure III-9 displays the cumulative distribution of benzene production facilities in the United States. Associated scales are included to show estimated profits from these operations and spill sizes under each methodology which would result in fines equal to these profits. It is noteworthy that over 20 percent of the benzene production facilities have capacities of less than 5 million gallons per year. Under the DOHM Methodology (worst case) a spill of 21 tons would eliminate net profits from the 5 million gallon per year operation. Under other approaches, these size operations are not nearly as threatened. For example, under the Resource Value Methodology a spill of over 2600 tons would be required to eliminate profits from the 5 million gallon per year unit.

Price Effects of Alternative Penalties

Under the DOHM penalty schedule a price increase of $0.0011/gallon (0.14 percent) by the representative production unit would be required to offset fines from the expected annual spillage of 4.58 tons per year. This price increase is considered insignificant as are price increases associated with other methodologies, all of which have penalty rates substantially lower than that of the DOHM Methodology. The production chain for benzene is illustrated in Figure III-10.

Maximum Fine

Table V-10 below summarizes the quantities of benzene which would have to be spilled from a stationarysource in order to reach the maximum penalty level.

TABLE III-10

QUANTITY OF BENZENE SPILLED
TO REACH MAXIMUM LIABILITY

Methodology	Quantity Spilled
IMCO	926 tons
Resource Value	5208 tons
Unit of Measurement	6757 tons
DOHM	42 tons

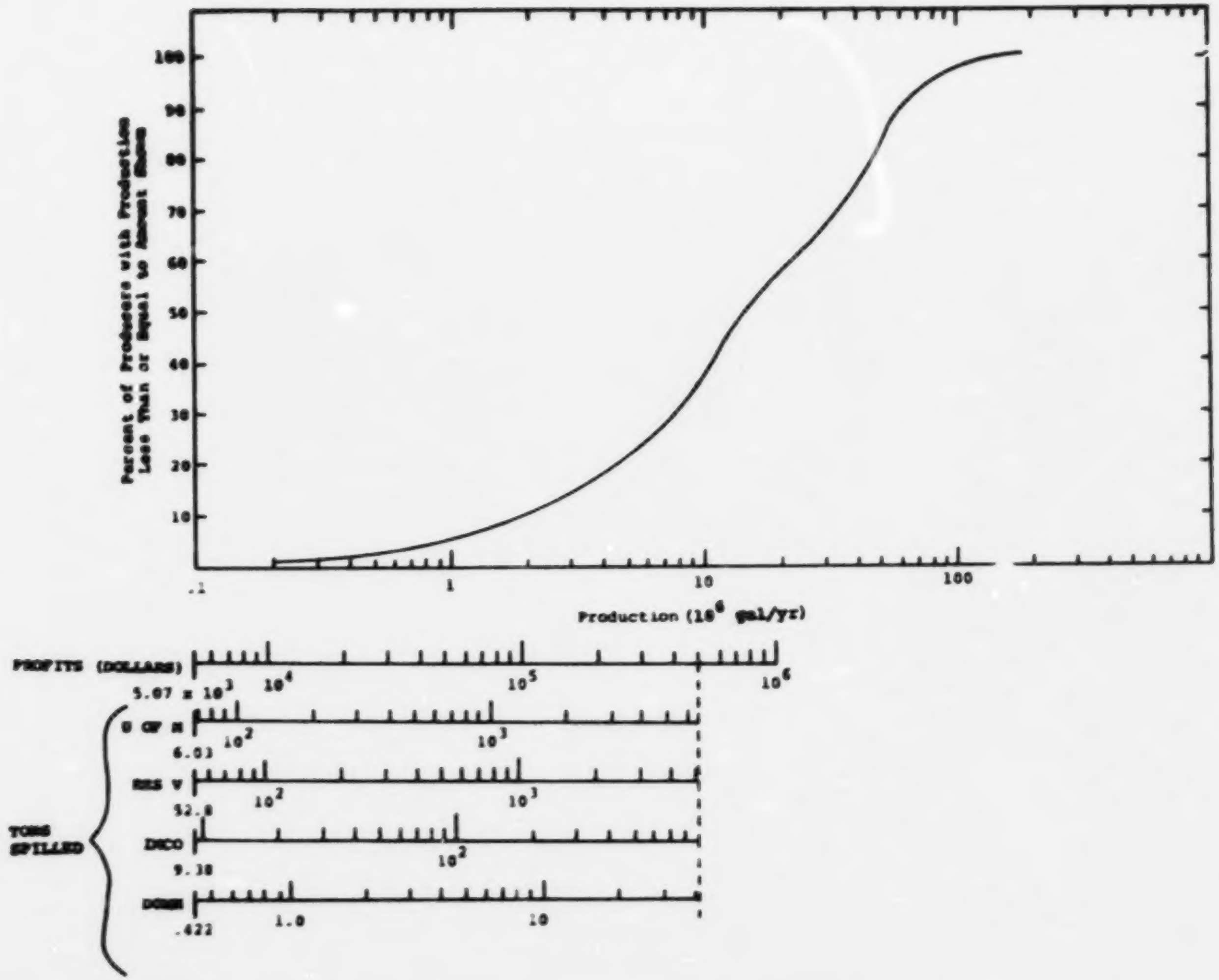

FIGURE III-9. CUMULATIVE DISTRIBUTION OF BENZENE PRODUCERS'

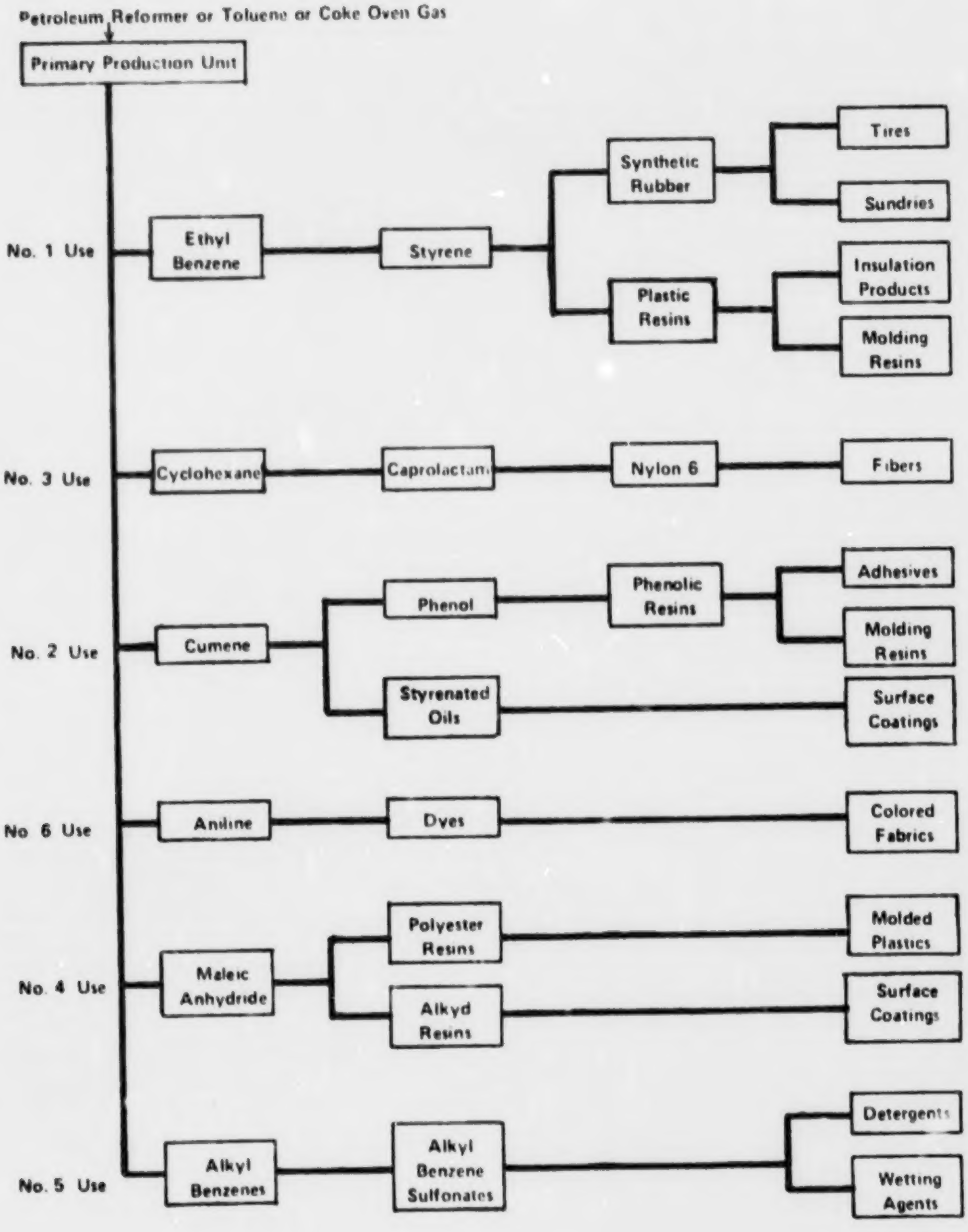
Petroleum Reformer or Toluene or Coke Oven Gas
Primary Production Unit
No. 1 Use
Ethyl Benzene
Styrene
Synthetic Rubber
Tires
Sundries
Plastic Resins
Insulation Products
Molding Resins
No. 3 Use
Cyclohexane
Caprolactam
Nylon 6
Fibers
No. 2 Use
Cumene
Phenol
Phenolic Resins
Adhesives
Molding Resins
Styrenated Oils
Surface Coatings
No 6 Use
Aniline
Dyes
Colored Fabrics
No. 4 Use
Maleic Anhydride
Polyester Resins
Molded Plastics
Alkyd Resins
Surface Coatings
No. 5 Use
Alkyl Benzenes
Alkyl Benzene Sulfonates
Detergents
Wetting Agents

FIGURE III-10. PRODUCT CHAIN FOR BENEZENE

With the possible exception of the DOHM Methodology, it is unlikely that these spill levels will ever be reached. Data from the Factory Mutual Research[6] study indicates that approximately 13 percent of the reported BTX spills are of the 42 ton size or greater.

Price increases required by the archetypical firm to offset the maximum liability are $0.01/gallon (1.27 percent).

Cross-Product Elasticity

In essence, there are not competitive substitutes for benzene with respect to the bulk of its uses.[7]

POTENTIAL ECONOMIC EFFECTS ON PHENOL PRODUCERS

The Representative Producer

A 200 million pound per year plant has been selected as the representative production unit. The average size production unit is about 183 million lbs/year. In 1973, there were only 14 production facilities that had a total annual production of 2.25 billion pounds (with a total capacity of 2.563 billion pounds).[6]

Annual revenues for the representative plant are estimated at $54 million, based on a $0.27 per pound sales figure.[2] Annual net profits are estimated to be $3.51 million.

Cost Effects of Alternative Penalties

Annual spillage of phenol has been calculated at 0.0025 percent of production. This figure was derived by taking reported annual spillage[3] and dividing this figure by annual production.* For the representative plant this equates to 2.53 tons per year. Fines for the annual spillage of this amount and the harmful quantity under each of the four methodologies are shown in Table III-11.

The figures in Table III-11 indicate that none of the penalty rates severely impact the representative producer. The two highest penalty rates, those for the IMCO and DOHM Methodologies, result in net profit reductions of less than one percent.

Marginal Firm

Figure III-11 indicates that the 50 million found per year (70 tons per day) plant is the smallest phenol production unit in

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*This figure represents a maximum average annual spillage, since the 0.0025 percent includes spillage during transport for which the shipper is not the responsible agent.

TABLE III-11

FINES FOR THE SPILLAGE OF PHENOL FROM A STATIONARY SOURCE INTO A RIVER

Methodology	Harmful Quantity	Rate of Penalty	Fine for the Spillage of a Harmful Quantity (Percent of Profits)	Fine for the Spillage of 2.53 Tons (Percent of Profits)
IMCO	760 lbs	$8.00/lbs	$6,080 (.17)	$40,377.96 (1.15)
Resource Value	1,600 lbs	$0.31/lbs	$ 496 (.01)	$ 1,564.03 (0.04)
Unit of Measurement	500 lbs	$0.98/lbs	$ 490 (.01)	$ 4,946.55 (0.15)
DOHM	1,200 lbs	$5.10/lbs	$6,120 (.17)	$25,739.70 (0.74)

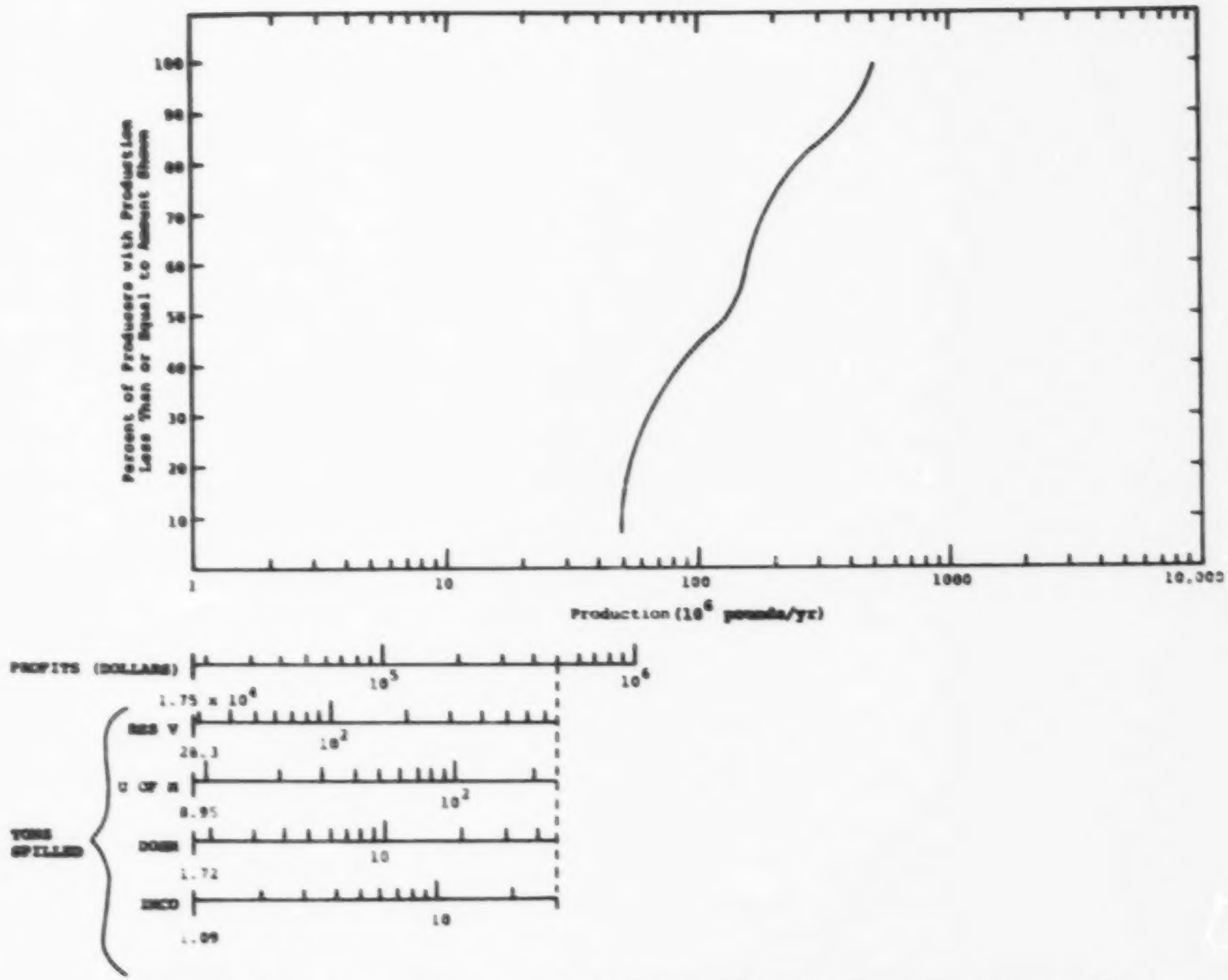

FIGURE III-11. CUMULATIVE DISTRIBUTION OF PHENOL PRODUCERS[a]

the United States. Calculated net profits for this size operation are $877,500 per year. This size operation could sustain the maximum liability and still show a profit. Even then, 31.25 tons of phenol would have to bespilled to reach this fine level under the highest penalty schedule (IMCO). This equates to 0.125 percent of annual production for the 50 million pound per year plant. This figure is over two orders of magnitude larger than the average annual spillage. The data available indicates that it is highly unlikely that any of the facilities presently engaged in the production of phenol would be irreversibly damaged by the penalties derived under any of the four methodologies.

Price Effects of Alternative Penalties

In order to cover anticipated fines which would result from the spillage of 2.53 tons per year, the representative producer would have to raise the prices of phenol $0.0001/lb (0.05 percent) if the worst case penalty schedule (IMCO) were used. This price increase, along with those associated with the other three methodologies is considered insignificant. The product chain for phenol is presented in Figure III-12.

Maximum Fine

The quantity of phenol which would have to be spilled under each of the four methodologies to reach the $500,000 maximum penalty is shown in Table III-12.

TABLE III-12

QUANTITY OF PHENOL SPILLED TO
REACH MAXIMUM LIABILITY

Methodology	Quantity Spilled
IMCO	31 tons
Resource Value	806 tons
Unit of Measurement	255 tons
DOHM	49 tons

A price pass-through of $0.0025 (0.93 percent) would be required by the representative producer to offset this maximum liability. Data from the Factory Mutual Research[6] study indicates that approximately 13 percent of the reported phenol* spills were 31 tons or larger.

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*Assuming 84 percent solution.

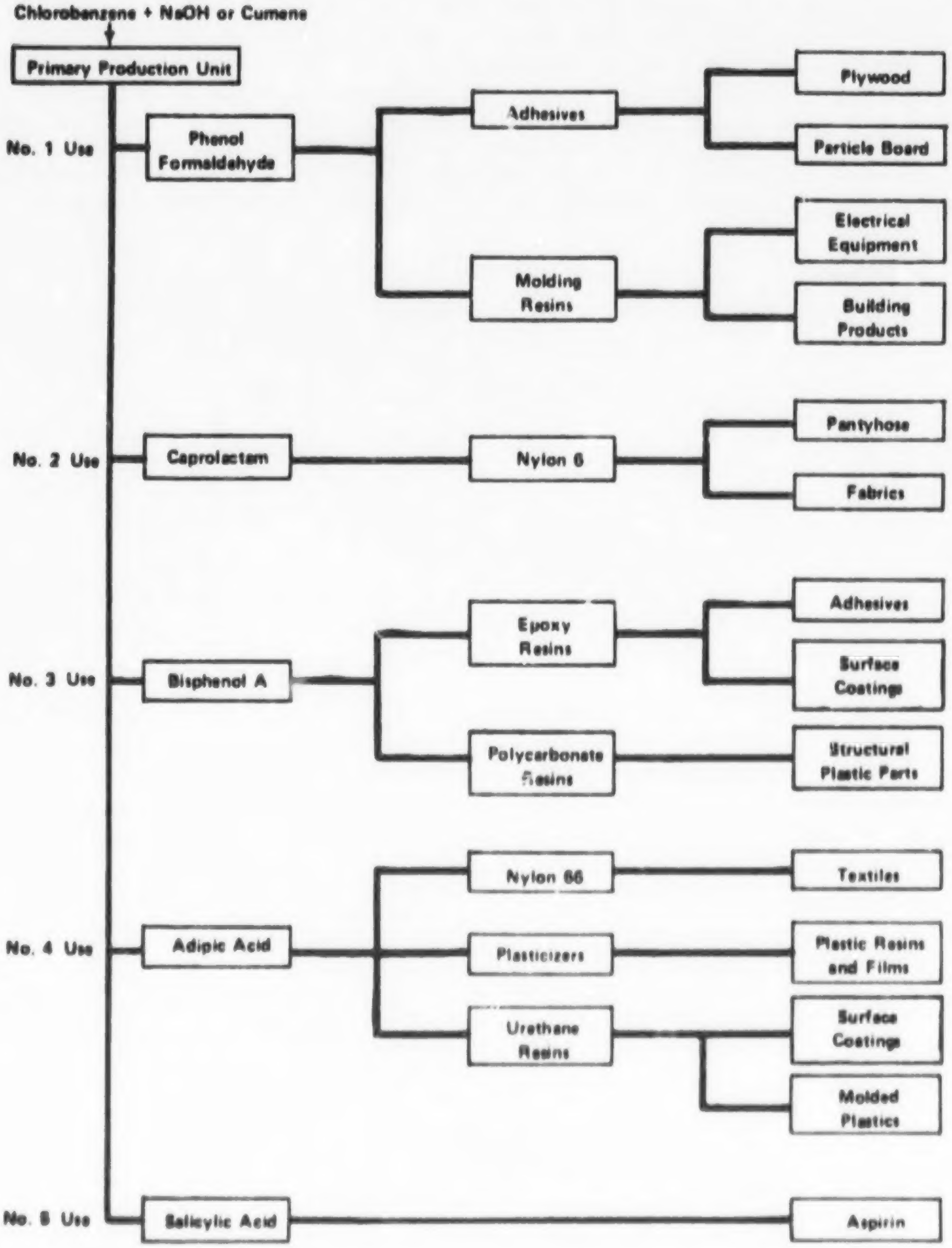
Chlorobenzene + NaOH or Cumene
Primary Production Unit
No. 1 Use
Phenol Formaldehyde
Adhesives
Plywood
Particle Board
Molding Resins
Electrical Equipment
Building Products
No. 2 Use
Caprolactam
Nylon 6
Pantyhose
Fabrics
No. 3 Use
Bisphenol A
Epoxy Resins
Adhesives
Surface Coatings
Polycarbonate Resins
Structural Plastic Parts
No. 4 Use
Adipic Acid
Nylon 66
Textiles
Plasticizers
Plastic Resins and Films
Urethane Resins
Surface Coatings
Molded Plastics
No. 5 Use
Salicylic Acid
Aspirin

FIGURE III-12. PRODUCT CHAIN FOR PHENOL

Cross-Product Elasticity

There are no competitive substitutes for phenol.

POTENTIAL ECONOMIC EFFECTS ON METHYL PARATHION PRODUCERS

Presently there are only three units actively engaged in the production of methyl parathion. For purposes of this report, these three plants have been labeled as Plant A (30 million pounds per year capacity); Plant B (12 million pounds per year capacity); and Plant C (50 million pounds per year capacity). In addition, another firm has a potential 28 million pounds capacity at Warners, New Jersey. A facility at Plaquemine, Louisiana, was deactivated in 1972. While the three active production units had 92 million pounds total capacity, only 68 million pounds were actually produced in 1972.[2] Capacities are flexible, and in many cases, can be used to make other organophosphorus pesticides.

Current prices range between 48-50¢ per pound, (80 percent methyl parathion) freight allowed.[2] At 48¢ per pound realized by the producer, annual revenues associated with the three operations are shown in Table III-13 along with net profits estimated on the basis of a 6.5 percent* profit margin.

TABLE III-13

ESTIMATED REVENUES AND NET PROFITS FOR METHYL PARATHION PRODUCTION UNITS

Production Facility	Capacity (Million Pound Per Year)	Estimated Revenue (10^6 Dollars)	Estimated Net Profit (10^3 Dollars)
Plant A	30	$14.40	$ 936.0
Plant B	12	$ 5.76	$ 374.4
Plant C	50	$24.00	$1,560.0

Spill history data from pesticide manufacturing facilities is unavailable. Furthermore, it would be misleading to assume that spill levels from these facilities are the same as those from facilities engaged in the production of less toxic materials. Material specifications and operating procedures at these facilities are judged to be stringent enough so as to substantially reduce the spill potential and hence preclude the use of the average spill figure (0.0025 percent of production) employed for some of the other materials.

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*It is likely that profit margins associated with this product are higher than 6.5 percent.

Since an acceptable estimate of annual spillage from this type of facility is not available, Table III-14 has been provided for use to estimate potential impacts on the profitability of these three operations for various size spills. Among other things, this table shows that spill sizes two to three orders of magnitude greater than the 0.0025 percent of production level would be required to incur fines equal to net profits or reach the $500,000 maximum penalty.

TABLE III-14

POTENTIAL IMPACTS OF PENALTY RATES* ON PRODUCERS OF METHYL PARATHION

Methodology	Plant A	Plant B	Plant C
I. IMCO			
A. Fine for Spillage of HQ (Percent of Net Profits)	$2,432 (0.26)	$2,432 (0.65)	$2,432 (0.16)
B. Percent Reduction in Net Profits Per 1000 lbs Spilled	0.43	1.07	0.26
C. Quantity Spilled to Incur Fines Equal to Net Profits or to Reach Maximum Liability. (Percent of Production)	62.50 tons (0.26)	46.80 tons (0.65)	62.50 tons (0.16)
II. Resource Value			
A. Fine for Spillage of HQ (Percent of Net Profits)	$ 304 (0.03)	$ 304 (0.08)	$ 304 (0.02)
B. Percent Reduction in Net Profits Per 1000 lbs Spilled	0.04	0.10	0.03
C. Quantity Spilled to Incur Fines Equal to Net Profits or to Reach Maximum Liability. (Percent of Production)	641 tons (4.27)	480 tons (8.00)	641 tons (2.56)
III. Unit of Measurement			
A. Fine for Spillage of HQ (Percent of Net Profits)	$ 226 (0.02)	$ 226 (0.06)	$ 226 (0.01)
B. Percent Reduction in Net Profits Per 1000 lbs Spilled	0.04	0.10	0.02
C. Quantity Spilled to Incur Fines Equal to Net Profits or to Reach Maximum Liability. (Percent of Production)	687 tons (4.58)	514 tons (8.56)	687 tons (2.75)
IIV. DOHM			
A. Fine for Spillage of HQ (Percent of Net Profits)	$2,475 (0.26)	$2,475 (0.66)	$2,475 (0.16)
B. Percent Reduction in Net Profits Per 1000 lbs Spilled	0.48	1.20	0.29
C. Quantity Spilled to Incur Fines Equal to Net Profits or to Reach Maximum Liability. (Percent of Production)	56 tons (0.37)	41.6 tons (0.69)	56 tons (0.22)

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*Penalty Rates are for the insoluble form 80 percent methyl parathion.

REFERENCES

1. Federal Register, Vol. 39, No. 164, Part IV, August 22, 1974.

2. Chemical Marketing Reporter, October 7, 1974.

3. Attaway, L. D. "Hazardous Materials Spills -- The National Problem," Proceeding of the 1972 National Conference on Control of Hazardous Material Spills, Houston, TX, March 21-23, 1972.

4. Stanford Research Institute, 1973 Directory of Chemical Producers, USA, SRI Chemical Information Service.

5. "Phosphatic Fertilizers, Properties and Process," Sulfur Institute, Washington, DC, 1974.

6. Buckly, J. L. and S. A. Weiner. Data collected during performance of contract No. 68-03-0317, "Historical Documentation of Hazardous Material Spills," Transmitted November 1974.

7. Little, A. D., Inc. "A Modal Economic and Safety Analysis of the Transportation of Hazardous Substances in Bulk," Contract C-76-446, U. S. Maritime Administration, May 1974.

8. Current Industrial Reports, Inorganic Chemicals, Series N28A, Bureau of Budget, 1972.

9. Chemical and Engineering News, January 1, 1974.

IV. ECONOMIC IMPACT ON MOBILE SOURCES

More than 300 chemical substances have been proposed[1] as potential candidates for designation as non-removable hazardous substances under paragraph (b)(2)(B)(i), Section 311 of PL 92-500.

For this study representative substances from the proposed list were selected for detailed analysis on the basis of annual production, chemical characteristics, and handling by three major transportation modes.

Based on these considerations, the following four chemical substances were chosen for impact analysis:

- Caustic Soda
- Sulfuric Acid
- Anhydrous Ammonia
- Chlorine

The impact of penalty levels developed under the four methodologies is analyzed with respect to an "average" carrier that is representative of a typical operator. Potential impacts or smaller, "marginal" operators in each mode are assessed by inspection of the distribution of carrier within each mode.

Impacts are analyzed by comparing the total yearly expected cost of penalties with the net income and the operating ratio of each average carrier. Comparison with income levels indicates the ability of the carrier's income to sustain the expected annual penalties. The operating ratio, on the other hand, shows the ratio of the expenses of doing business to the total income generated by the business. The analysis of the operating ratio shows the extent of "loss" in profitability due to penalties.

The annual penalty cost to an average carrier is the penalty rate per unit multiplied by the total units spilled summed for all spill incidents in a year. Although penalty rates per unit are known, spill quantities per incident as the number of spill incidents per year for an "average" and a "marginal" carrier are difficult to estimate. Historical data in these areas are not available in sufficient detail and breadth to permit accurate estimates of spill quantities and number of spill incidents. Therefore, it was decided to analyze the impacts of penalty levels upon the net income and operating ratio for a range of spill sizes and for an incidence of one spill per year.

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[1] Federal Register, Vol. 39, No. 164, Part IV, August 22, 1974.

The lower value for the range of spill quantities is taken to be equal to the harmful quantity levels shown in Table IV-1. The upper limit of the range is based on the largest size of the vehicle used in shipping the chemical. Additionally, the percentage decrease in net profit and absolute increase in operating ratio per 1000 pounds of material spilled is also computed.

Recent published financial and operating statistics of individual carriers were used in computing the net income and operating ratio of an average and marginal carrier engaged in motor and rail transport. For the motor carriers a sample of 39 common and contract operators transporting the four chemicals was selected and the average net income and operating ratio for 1971 were computed. For the rail carriers, 1972 net income and operating ratio for an average carrier were computed from data published by the AAR for 63 Class I railroads. These companies represent 99 percent of the railroad industry in terms of traffic, 96 percent in terms of rail mileage, and 93 percent in terms of workers employed by railroad companies.

Because most inland waterway operators are not regulated by ICC they are not subject to the commission's reporting requirements. Therefore, no published financial and operating data are available to compute net income and operating ratio for an average and marginal barge operator. In the absence of published data the following approach was used: operating conditions of typical barge movement in the New Orleans area including different tow types and barge configurations were determined. From these descriptions annual operating cost estimates per tow and barge operator were made. In the following discussions the impacts are analyzed separately for motor carriers, railroads, and barge operators.

MOTOR-CARRIER OPERATIONS

Intercity movements of chemicals and allied products by truck has been largely confined to short distances. In 1970, 42.8 percent of intercity tons of chemicals were moved by for-hire and private trucks. On the other hand, the share of intercity ton-miles attributed to trucks was only 19.7 percent. Noteworthy is the fact that shorter hauls are generally performed by private carriers, whereas longer hauls are generally done

TABLE IV-1

HARMFUL QUANTITIES AND PENALTY RATES FOR RIVERS

	Anhydrous Ammonia	Chlorine	Caustic Soda	Sulfuric Acid
Harmful Quantity (lbs)				
DOHM	330.00	9.70	9,600.000	12,000.000
IMCO	760.00	69.00	7,600.000	7.600.000
Resource Value	460.00	14.00	13,000.000	17,000.000
Unit of Measurement	500.00	50.00	5,000.000	5,000.000
Penalty Rate ($/lb)				
Cost of Prevention				
Barge	9.30	6.40	6.000	5.800
Rail	0.68	0.47	0.440	0.420
Truck	7.20	4.90	4.700	4.500
IMCO	4.70	66.00	.600	.600
Resource Value	1.10	37.00	.037	.036
Unit of Measurement	.57	8.40	.073	.073

by for-hire common and contract carriers. The average length of haul for private and for-hire carriers has been 150 and 211 miles, respectively. Approximately 67 percent of the total tons that move by truck are shipped by for-hire carriers, and 72 percent of tone-miles are generated by for-hire carriers.[2] The reason for this difference in length of haul appears to be the preference of chemical manufacturers to use their private fleets for interplant transfers of products to their nearby processing facilities.

These figures indicate that the for-hire carrier is the principal motor carrier both in terms of tons and ton-miles. For this reason and because the private carriers are owned and operated by chemical manufacturers (against whom any fines would be levied), the impact analysis in this section is directed toward the for-hire motor carriers.

Average Motor Carriers

Data on the financial and operating statistics for Class I and II motor carriers are available form the American Trucking Association, Inc.. The annual statistics for the years 1970 and 1971 indicate that 3,034 contract and common motor carriers were operating in the United States. The annual report presents operating and financial statistics for 2,643 carriers. The statistics do not provide a means of identifying the average finanical and operating statistics for motor carriers that transport caustic soda, chlorine, sulfuric acid and anhydrous ammonia. To generate an average profile of common and contract motor carriers that handle these materials, a list of carriers was prepared from the U. S. Department of Transportation spill data for 1971. This data afforded the following information on the four materials of concern.

(a) Anhydrous Ammonia. The Office of Hazardous Materials, U. S. Department of Transportation (DOT/OHM) reports a total of 36 spills of anhydrous ammonia in 1971. Of these, 16 were from for-hire motor carriers, 19 from railroads, and one from a private hauling company.

(b) Chlorine. Of the 11 spills of chlorine reported in the same source for 1971, none were attributed to for-hire motor carriers.

(c) Caustic Soda. Twenty-five spills of caustic soda were reported for 1971. Of these, 12 were from railroads, one from a private barge operator, and 12 from for-hire motor carriers.

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[2] U. S. Department of Transportation, Transportation Projections, 1970-1980, July, 1971.

(d) Sulfuric Acid. Of the 78 spill incidents of sulfuric acid in 1971, 56 were from for-hire motor carriers, 20 from railroads, and 2 from private operators.

From these incidents a set of 39 motor carriers involved in the spillage of the four hazardous materials was obtained. Consolidated financial and operating statistics for these 39 motor carriers are contained in Table IV-2.

From the financial and operating statistics of the firms shown in Table IV-2, characteristics of the average motor-carrier were derived. These characteristics are summarized in Table IV-3. It should be noted that none of these carriers exclusively specializes in moving caustic soda, anhydrous ammonia, or sulfuric acid. Furthermore, the list is not an exhaustive sample of all for-hire motor carriers moving these chemicals. Nevertheless, the list provides a sample of motor carriers that handle the subject materials containing both large and small carriers with a broad geographic coverage.

Estimated Impacts of Penalty Rates

Impacts of the various methodology penalty rates on the average motor carrier's profits and operating ratio are summarized in Table IV-4. This table depict the impacts which result from the spillage of the harmful quantity and the maximum container size (30 ton truck) in terms of the percentage decrease in net profits and the increase in operating ratio for the average carrier. Additionally, the change per 1000 pounds of material spilled is also computed and can be used as a linear rate constant to compute the impacts of any size spill. Calculations were performed assuming spillage into a river.

From these tables the following specific conclusions can be drawn:

- None of the penalty rates for the four materials studied, even with the spillage of a 30 ton truck load, is high enough to completely eliminate annual net profits.

- The $500,000 maximum liability was reached by all methodologies except the DOHM Methodology for the spillage of a 30 ton truckload of chlorine.

- For all chemicals the impact on net profits exceeds 20 percent under the DOHM Methodology from the

TABLE I -2

FINANCIAL AND OPERATING STATISTICS FOR SELECTED CLASS I AND II MOTOR CARRIERS OF SULFURIC ACID, CAUSTIC SODA, AND ANHYDROUS AMMONIA FOR 1971³

Carrier	Operating Revenues Intercity Freight (10^3 dollars)	Operating Revenues Total (10^3 dollars)	Total Expenses (10^3 dollars)	Net Operating Revenue (10^3 dollars)	Net Income (10^3 dollars)	Oper-ating Ratio	Total Vehicle Miles (10^3)	Total Tons (10^3)	Expense Per Vehicle Mile (dollars)
Allyn Transportation Co.	3,560.6	5,259.0	5,088.5	170.5	95.0	96.8	5,105.5	680.9	.9967
Associated Transportation, Inc.	128,177.4	128,224.6	127,026.8	1,197.8	-262.0	99.1	114,571.7	2,581.4	.8217
Arizona Tank Lines, Inc.	4,303.3	4,396.6	4,314.8	81.9	30.2	98.1	9,027.9	1,932.0	.4779
Barton Truck Line, Inc.	2,583.1	2,603.4	2,390.8	212.6	144.8	91.8	743.1	147.9	2.5224
Bowman Transportation, Inc.	54,949.2	54,949.2	47,962.2	6,987.0	3,269.7	87.3	61,405.4	1,639.7	.6491
Bridges Brothers	804.0	804.0	739.7	64.3	9.2	92.0	1,853.1	137.1	.3992
Briggs Transportation Co.	22,625.4	22,657.5	20,916.1	1,741.5	1,057.7	92.3	14,326.9	521.6	1.0187
Chemical Haulers, Inc.	1,365.2	1,457.7	1,397.9	59.8	26.2	95.9	1,727.2	124.0	.8093
Consolidated Freight Ways	303,335.1	305,519.1	278,430.8	27,088.4	13,183.2	91.1	257,481.8	3,883.0	.7931
Dahlen Transport, Inc.	3,981.4	4,813.2	4,528.2	285.0	167.1	94.1	7,095.8	1,085.0	.6382
Delta Lines, Inc.	32,336.8	32,415.1	30,951.9	1,463.2	924.2	95.5	12,258.1	714.3	1.7665
Garrett Freight Lines, Inc.	62,312.4	62,371.6	56,664.7	5,706.9	2,972.2	90.9	51,354.2	1,086.2	.8120
General Expressways, Inc.	23,104.2	23,105.2	22,005.2	1,100.0	472.7	95.2	21,377.5	578.7	.8894
Georgia Highway Express, Inc.	29,291.0	29,368.4	26,760.1	2,608.2	1,404.4	91.1	14,904.0	852.6	1.2547
Gordons Transports, Inc.	48,511.1	48,598.3	45,017.5	3,580.7	1,905.2	92.6	38,786.6	1,019.3	.8704
Greenleaf Motor Express, Inc.	801.0	811.3	821.0	-9.7	-36.3	101.2	1,161.7	65.8	.7100
Groendyke Transport, Inc.	16,701.5	18,026.0	16,432.3	1,593.8	897.2	91.2	36,863.0	3,336.2	.4458
Jones Motor	63,600.4	63,687.2	63,628.3	58.9	122.0	99.9	62,724.8	1,668.6	.7993
Klipsch Hauling Co.	368.3	784.6	778.3	6.3	-5.0	99.2	426.6	32.5	1.8244
Matlock, Inc.	60,933.8	61,996.5	57,749.4	4,247.1	2,376.3	93.1	84,109.6	11,065.5	.6866
McLean Trucking Co.	178,964.1	179,153.0	165,536.5	13,616.6	6,313.9	92.4	164,011.4	2,885.1	.7635
Miller Transporters, Inc.	13,886.8	13,980.5	12,890.2	1,090.3	624.8	92.5	24,782.6	3,391.8	.5199
Navajo Freight Lines, Inc.	47,122.4	47,548.5	45,044.3	2,504.2	1,096.8	94.7	51,022.3	686.9	.7183
OMC Motor Freight System	41,375.8	41,439.1	38,131.3	3,307.8	1,882.7	92.0	25,122.2	775.0	1.1372
Reading Transportation Co.	4,125.4	4,358.3	4,067.1	291.2	279.5	93.3	2,304.4	209.8	1.4006
Red Ball Motor Freight, Inc.	53,357.5	53,457.5	52,585.5	872.0	357.0	98.4	36,440.6	1,334.0	.9855
Rio Grande Motorway, Inc.	10,456.4	11,487.5	11,462.4	25.1	19.6	99.6	6,896.9	337.2	1.1711
Roadway Express, Inc.	8,976.8	8,976.8	7,030.0	1,946.8	1,262.3	78.3	5,088.7	257.9	.8979
Robertson Tank Lines, Inc.	18,266.0	18,301.9	17,266.6	1,035.3	486.6	94.3	34,811.4	3,646.0	.4855
Rogers Cartage Co.	16,420.6	17,372.4	16,555.7	816.7	466.0	95.3	22,420.1	1,754.4	.7384
Ruan Transport Corp.	31,871.7	31,933.9	29,775.9	2,158.0	155.2	93.2	50,313.3	8,411.2	.5918
Shills Motor Lines, Inc.	1,299.5	1,372.9	1,320.4	52.5	20.5	96.2	2,241.1	165.4	.5814
Schwerman Trucking Co.	44,093.2	48,524.6	44,738.3	3,786.3	1,882.1	92.2	69,811.4	10,205.5	.6804
South Bend Freight Line, Inc.	4,075.6	4,308.7	4,281.4	27.4	59.8	99.4	2,139.6	280.7	1.7109
South Western Motor Transport	5,386.5	5,434.0	4,486.4	947.6	478.2	82.6	3,475.3	197.4	.9215
Stevens Tank Lines, Inc.	6,434.8	6,446.0	6,458.5	-12.6	-85.4	100.2	12,633.4	1,388.1	.5112
Strickland Transp. Co., Inc.	43,415.7	43,422.3	40,064.2	3,358.1	2,630.6	92.3	42,845.0	655.1	.7188
Whitfield Tank Lines, Inc.	4,077.2	4,080.8	3,839.7	241.2	128.3	94.1	8,120.5	877.7	.4728
Younger Brothers, Inc.	5,204.1	5,280.9	5,170.7	110.3	36.5	97.9	10,322.3	666.9	.5008
TOTAL	1,402,595.3	1,418,688.1	1,324,309.7	94,378.8	46,760.8		1,372,087.3	71,202.2	
AVERAGE PER CARRIER	35,964.0	36,376.6	33,956.7	2,420.0	1,199.0	93.3	35,182.0	1,825.7	.7645

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²Full Year 1971-1970 Report of the American Trucking Association, Inc.

TABLE IV-3

CHARACTERISTICS OF AVERAGE AND MARGINAL FOR-HIRE MOTOR CARRIERS

Net Income (10^3 dollars)	1,119.000
Total Operating Revenue (10^3 dollars)	36,376.600
Total Expenses (10^3 dollars)	33,956.700
Total Tons (10^3 Tons)	1,825.700
Income/Ton (dollars)	.657
Revenue/Ton (dollars)	19.920
Expenses/Ton (dollars)	18.60
Operating Ratio (expenses/revenues)	93.35

spillage of a 30 ton truck. With the other methodologies, substantial impacts (>20%) result only from the spillage of chlorine and in the case of the IMCO Methodology, ammonia.

- For all methodologies and chemicals, the spillage of one harmful quantity does not substantially impact the average motor carrier.

Although the average net income of the 39 motor carriers comprising the sample set appears sufficiently high to absorb the penalties, a significant portion of carriers have income levels so low that their full year's net income could be eradicated by a major spill. Table IV-5 ranks the 39 motor carriers comprising the sample set from lowest to highest on the basis of annual net income. From this table a cumulative distribution based on annual net income can be plotted for these motor carriers. This curve shown in Figures IV-1 (A-D) can then be used to assess the impacts of various size spills of each material for each methodology on

TABLE IV-4

SUMMARY OF FINE IMPACTS ON AVERAGE MOTOR CARRIER RESULTING FROM THE SPILLAGE OF SELECTED HAZARDOUS MATERIALS INTO A RIVER

Spilled Material	DOHM			IMCO			Resource Value			Unit of Measurement		
	Spillage of the Harmful Quantity	Spillage of the Maximum Container	Change Per 1000 Pounds Spilled	Spillage of the Harmful Quantity	Spillage of the Maximum Container	Change Per 1000 Pounds Spilled	Spillage of the Harmful Quantity	Spillage of the Maximum Container	Change Per 1000 Pounds Spilled	Spillage of the Harmful Quantity	Spillage of the Maximum Container	Change Per 1000 Pounds Spilled
1. Percentage Decrease in Annual Net Profit												
Anhydrous Ammonia	0.20	35.81	0.60	0.30	23.42	0.39	0.04	5.43	0.09	0.02	2.85	0.05
Chlorine	0.00	24.68	0.41	0.38	41.70	5.50	0.04	41.70	3.07	0.03	41.70	0.70
Caustic Soda	3.72	23.27	0.39	0.38	3.01	0.05	0.04	0.19	0.00	0.03	0.37	0.01
Sulfuric Acid	4.42	22.27	0.37	0.38	3.01	0.05	0.05	0.16	0.00	0.03	0.37	0.01
2. Increase in Operating Ratio												
Anhydrous Ammonia	0.00	1.18	0.02	0.01	0.77	0.01	0.00	0.18	0.00	0.00	0.09	0.00
Chlorine	0.00	0.81	0.01	0.01	1.37	0.18	0.00	1.37	0.10	0.00	1.37	0.02
Caustic Soda	0.12	0.76	0.01	0.01	0.10	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Sulfuric Acid	0.14	0.73	0.01	0.01	0.10	0.00	0.00	0.00	0.00	0.00	0.01	0.00

TABLE IV-5

MOTOR CARRIERS RANKED BY NET INCOME

Motor Carrier	Net Income ($000)
Associated Transportation, Inc.	-262.0
Steere Tank Lines, Inc.	- 85.6
Greenleaf Motor Express, Inc.	- 36.3
Klipsch Hauling Company	- 5.0
Bridges Brothers	9.2
Rio Grande Motorway, Inc.	19.6
Schilli Motor Lines, Inc.	20.5
Chemical Haulers, Inc.	26.2
Arizona Tank Lines, Inc.	30.2
Younger Brothers, Inc.	36.5
South Bend Freight Line, Inc.	59.8
Allyn Transportation Company	95.0
Whitfield Tank Lines, Inc.	120.3
Jones Motor	122.0
Barton Truck Line, Inc.	144.8
Ruan Transport Corporation	155.2
Dahlan Transport, Inc.	167.1
Reading Transport Company	279.5
Red Ball Motor Freight, Inc.	357.0
Rogers Cartage Company	466.0
General Expressway, Inc.	472.7
South Western Motor Transport	478.2
Robertson Tank Lines, Inc.	486.6
Miller Transport, Inc.	624.8
Groendyke Transport, Inc.	897.2
Delta Lines, Inc.	924.2
Briggs Transportation Company	1,057.7
Navajo Freight Lines, Inc.	1,096.8
Roadway Express, Inc.	1,262.3
Georgia Highway Express, Inc.	1,404.4
Schwerman Trucking Company	1,802.1
ONC Motor Freight System	1,882.7
Gordon's Transports, Inc.	1,905.2
Matlock, Inc.	2,376.3
Strickland Transport Company, Inc.	2,630.6
Garrett Freight Lines, Inc.	2,972.2
Bowman Transportation, Inc.	3,269.7
McLean Trucking Company	6,313.9
Consolidated Freightways	13,183.2

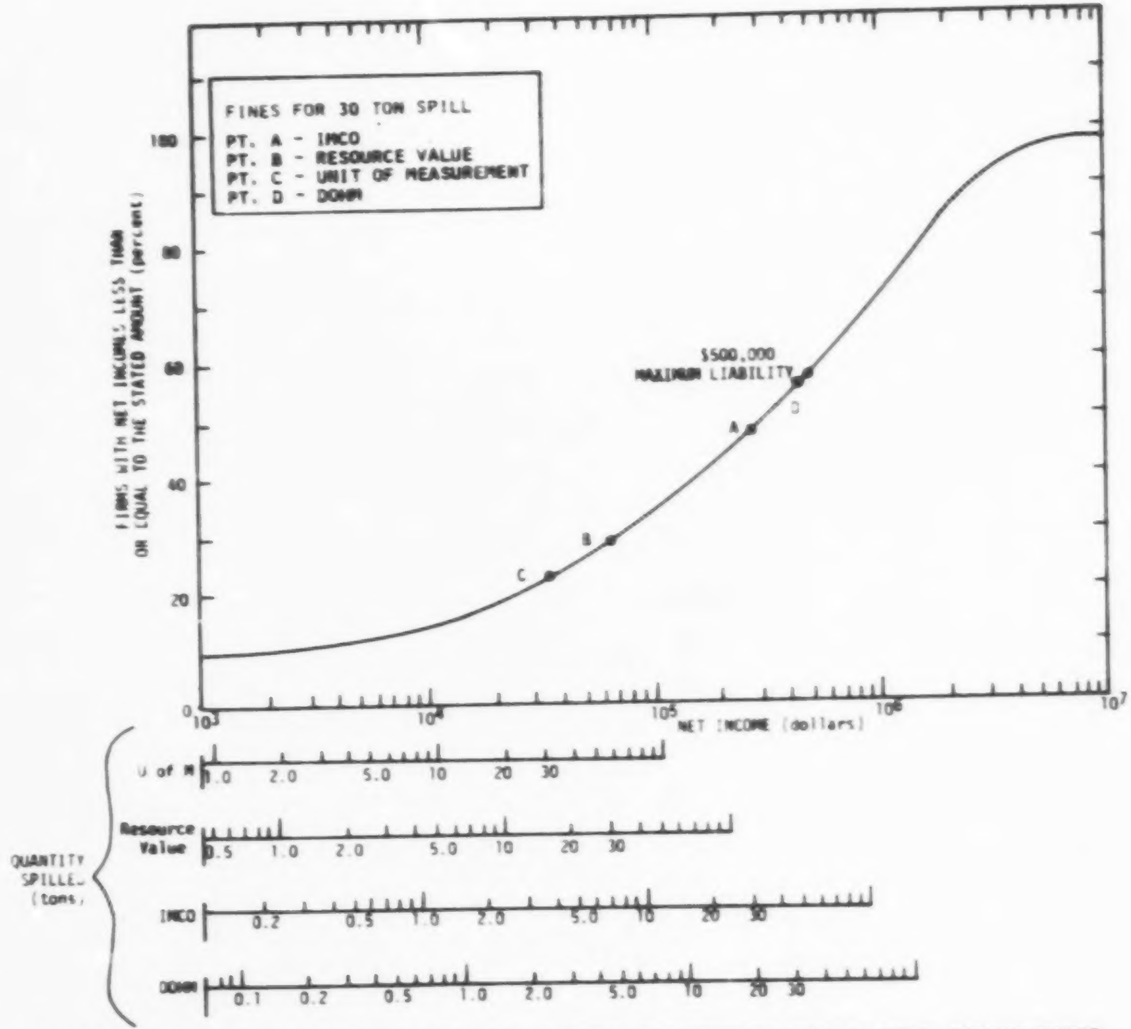

FIGURE IV-1 (A). IMPACTS OF FINES ON MOTOR CARRIERS RESULTING FROM THE SPILLAGE OF ANHYDROUS AMMONIA

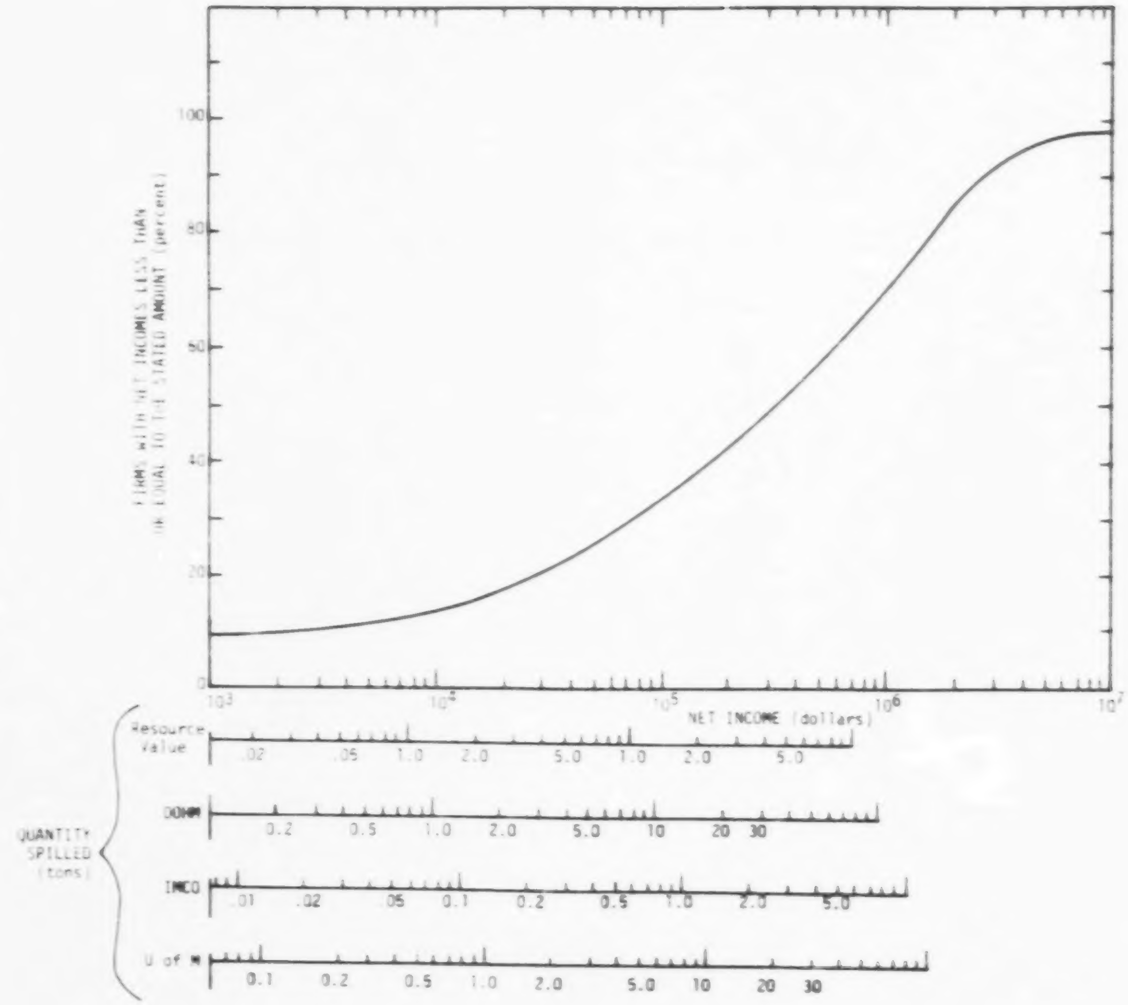

FIGURE IV-1 (B). IMPACTS OF FINES ON MOTOR CARRIERS RESULTING FROM THE SPILLAGE OF CHLORINE

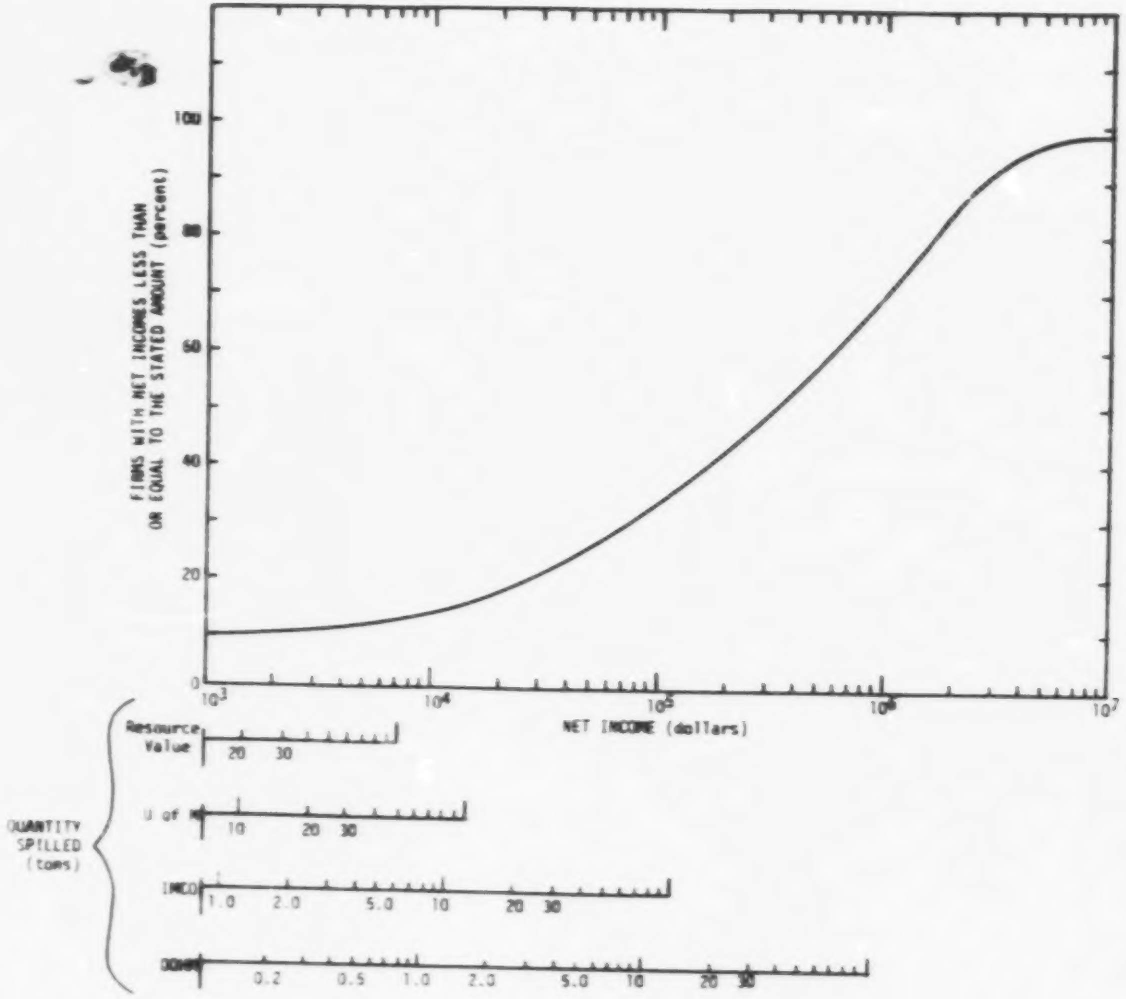

FIGURE IV-1 (C). IMPACTS OF FINES ON MOTOR CARRIERS RESULTING FROM THE SPILLAGE OF CAUSTIC SODA

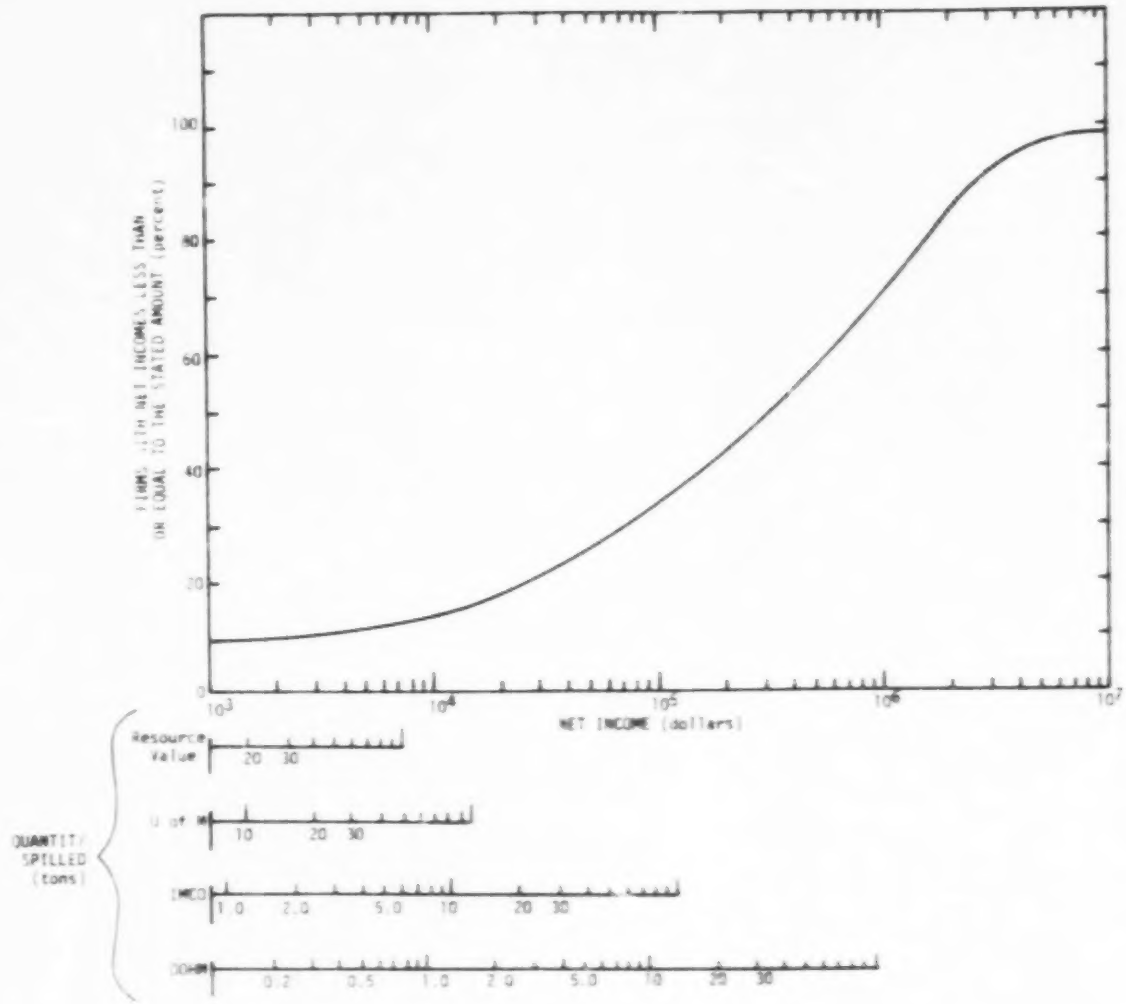

FIGURE IV-1 (D). IMPACT OF FINES ON MOTOR CARRIERS RESULTING FROM THE SPILLAGE OF SULFURIC ACID

1) the individual firms of the sample set, 2) the industry (as represented by the sample set), or 3) any other motor carriers whose net income is known. As an example, consider Figure IV-1(A) for anhydrous ammonia. For a given size spill the fine under each of the four methodologies can be readily determined by simply reading between any one of the four lower scales, quantity spilled (tons), and the net income scale (dollars). Additionally the curve in this figure can be used to estimate the percentage of motor carriers whose annual net profits would be equaled or exceeded by 1) a fine equal to a given dollar amount (net income scale) or 2) for a given methodology, the spillage of a given amount of material (quantity spilled scale). Points A, B, and C, for example, show the percentage of carriers whose profits are equaled or exceeded by fines resulting from the spillage of a 30 ton tank truck of anhydrous ammonia under the IMCO, Resource Value, and Unit of Measurement Methodologies respectively. Under the DOHM Methodology the spillage of a 30 ton truck results in a fine of $432,000 (Point D). Similarly, curves given in Figures IV-1 (B-D) can be used for chlorine, caustic soda, and sulfuric acid, respectively.

Summary of Impacts on Motor Carriers

For the average carrier, as derived in this section, the maximum effect on net income is a 41.7 percent loss resulting from the imposition of the maximum $500,000 fine. Of the four methodologies and the four chemicals studied, this level was reached by three of the four methodologies when a 30 ton truck load of chlorine was spilled. However, even at the maximum fine level, the loss could be fully recovered by increasing the motor freight cost per ton by $0.27 to $18.87. It is not expected that the average motor carrier would experience a serious loss of business to other modes due to a rate increase of $0.27 per ton. The average F.O.B. cost for commercial shipments of the four chemicals in 1969 was $33.73 per ton, a figure judged sufficiently high to absorb a $0.27 increase in motor freight costs.

Depending on the methodology use, the impacts of penalty rates on the smaller firms can be quite severe. Table IV-6 shows the percentage of firms whose annual net profits would be equaled or exculded by fines resulting from the spillage of a 30 ton truckload of a given material into water. This table was derived from Figure IV-1 (A-D) which uses the sample set of 39 motor carriers to represent the industry size distribution.

TABLE IV-6

PERCENTAGE OF MOTOR-CARRIERS WHOSE ANNUAL NET PROFITS ARE EQUALED OR EXCLUDED BY FINES FROM THE SPILLAGE OF 30 TON TRUCKLOAD OF VARIOUS HAZARDOUS MATERIALS

	Methodology			
Hazardous Materials	DOHM	IMCO	Resource Value	Unit of Measurement
Anhydrous Ammonia	58*	49	28	23
Chlorine	50	58*	58*	58*
Caustic Soda	48	22	11	12.5
Sulfuric Acid	48	22	11	12.5

*Maximum Liability Reached

This table indicates that a significant number of the smaller operators could be severely impacted (at least in any one given year) in the event that they were found to be responsible for the release of a full truckload of any one of the four materials.

RAILROAD OPERATIONS

All transporation of chemicals bv rail is regulated by the Interstate Commerce Commission. About 56 percent of intercity tons and 65 percent of ton-miles are moved by rail. The average rail length of haul for chemicals is approximately 600 miles.[a] Compared to the average length of haul for motor carriers (280 miles), it is clear that the rail mode is preferred over trucking for longer distances.

Table IV-7 presents selected statistics from the condensed income statements for 63 Class I railroads for 1972. These companies represent about 99 precent of the railroad industry in terms of traffic. Of the 63 carriers 19 had a net loss ranging from $14 thousand (Greenbay and Western) to $233 million (Penn Central). The average annual net income is $6.2 million per carrier; the average operating ratio is 78.7. Characteristics for the average rail carrier used in this study are shown in Table IV-8.

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[a] 1974 Yearbook of Facts, American Association of Railroads, AAR, Washington, DC, February 1974.

TABLE IV-7

1972 SELECTED STATISTICS FROM CONDENSED INCOME STATEMENTS FOR 63 CLASS I RAILROADS[3]

District and Road	Avg. Miles of Road Operated	Total Operating Revenues	Total Operating Expenses	Net Railway Operating Income: Amount	Net Railway Operating Income: Rate of Return on Average Net Investment	Net Income[a]
EASTERN DISTRICT						
Akron, Canton & Youngstown RR	171	$ 7,613,886	$ 6,917,020	$ 550,090	2.93%	$ 81,465
Ann Arbor RR	299	11,002,965	10,239,935	Def 1,104,768	Def	Def 1,958,226
Baltimore & Ohio RR	5,501	502,383,559	367,697,239	36,509,994	3.67	10,444,902
Bangor & Aroostook RR	542	13,752,357	14,720,125	2,744,297	4.42	2,057,354
Bessemer & Lake Erie RR	220	47,600,188	35,377,275	5,045,257	6.51	5,346,931
Boston & Maine Corporation	1,463	77,298,220	69,289,126	Def 5,504,101	Def	Def 11,641,058
Canadian Pacific (Lines in ME)	234	8,885,643	7,504,380	Def 511,02[illegible]	Def	Def -
Central RR of New Jersey	402	41,504,088	39,015,446	Def 6,328,7[illegible]	Def	Def 5,501,291
Central Vermont Ry	382	10,062,021	8,193,376	1,185,093	5.40	595,571
Chesapeake & Ohio Ry	4,994	451,330,041	343,948,922	52,412,001	5.84	32,869,313
Chicago & Eastern Illinois RR	643	39,578,470	29,166,827	3,339,744	4.84	2,715,395
Delaware & Hudson Ry	717	41,833,059	33,278,922	1,240,749	1.45	1,067,981
Detroit & Toledo Shore Line RR	50	8,264,867	5,775,641	877,868	5.84	815,944
Detroit, Toledo & Ironton RR	476	41,724,400	30,850,853	3,997,777	5.68	3,415,553
Elgin, Joliet & Eastern Ry	205	72,544,409	53,577,188	4,608,603	7.24	6,342,631
Erie Lackawanna Ry	2,864	263,594,164	223,168,658	Def 7,744,375	Def	Def 23,541,107
Grand Trunk Western RR	946	89,887,540	80,185,085	Def 13,943,533	Def	Def 18,306,702
Illinois Terminal RR	191	12,390,078	9,672,781	1,313,163	6.56	831,980
Lehigh Valley RR	972	51,129,082	47,786,668	Def 8,941,873	Def	Def 17,693,020
Long Island RR	327	94,311,703	146,694,173	Def 65,987,179	Def	Def 63,395,559
Maine Central RR	908	28,209,093	25,205,952	1,028,792	1.67	124,553
Missouri-Illinois RR	334	7,666,965	6,403,391	3,152,030	7.88	2,705,281
Monongahela Ry	184	8,378,908	5,204,812	1,920,249	4.05	Def 337,609
Norfolk & Western Ry	7,616	795,010,000	565,835,670	130,275,020	6.43	32,149,728
Penn Central Transportation Co.	19,861	1,825,456,301	1,535,027,115	Def 105,238,001	Def	Def 222,829,250
Penna-Reading Seashore Lines	311	9,043,719	11,184,498	Def 5,065,453	Def	Def 5,690,211
Pittsburgh & Lake Erie RR	211	37,531,775	39,684,419	10,661,114	4.83	9,195,265
Reading Company	1,171	111,150,115	102,755,748	Def 12,125,587	Def	Def 20,083,342
Richmond, Fred'burg & Potomac	110	25,192,484	14,598,555	5,511,873	9.53	9,302,269
Western Maryland Ry	861	48,880,278	42,033,203	4,759,303	3.10	Def 630,156
TOTAL EASTERN DISTRICT	53,366	3,910,993,003	3,910,993,003	38,638,333	0.37	Def 271,545,415
SOUTHERN DISTRICT						
Clinchfield RR	295	40,214,621	24,814,496	10,816,311	9.13	-
Florida East Coast Ry	530	39,511,843	23,306,700	5,469,889	7.10	6,267,365
Georgia RR	322	11,189,131	9,285,624	196,709	0.95	-
Illinois Central Gulf RR[b]	9,658	472,606,516	373,439,460	27,443,335	*2.74	*27,937,290
Louisville & Nashville RR	6,588	458,478,204	359,795,562	46,578,173	4.39	29,002,328
Norfolk Southern	622	15,362,715	12,778,072	566,800	1.55	18,979
Seaboard Coast Line RR	9,099	563,136,507	420,662,316	49,800,649	4.62	50,606,325
Southern Railway System[c]	10,022	723,798,000	509,135,000	120,937,000	7.73	85,335,000
TOTAL SOUTHERN DISTRICT	36,595	2,301,405,733	1,716,438,804	258,762,609	*5.32	*208,451,582

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[3] American Association of Railroads. 1974 Yearbook of Facts, AAR, Washington, DC, February 1974.

TABLE IV-7 (Cont'd)

District and Road	Avg Miles of Road Operated	Total Operating Revenues	Total Operating Expenses	Net Railway Operating Income				
					Amount	Rate of Return on Average Net Investment		Net Income[a]
WESTERN DISTRICT								
Atchison, Topeka & Santa Fe Ry	12,651	$ 831,695,396	$ 647,310,185		$ 86,763,954	3.31%		$ 80,866,[illegible]
Burlington Northern Inc.	23,410	1,000,516,581	827,620,927		48,200,139	2.08		40,961,[illegible]
Chicago & North Western Trans.Co.[d]	10,556	360,709,287	286,657,349		18,855,224	3.96		11,299,652
Chicago, Milwaukee, St. Paul&Pac RR	10,371	312,831,667	265,410,661	Def	6,783,161	Def	Def	8,643,111
Chicago, Rock Island & Pacific RR	7,495	305,290,186	246,138,116	Def	5,502,501	Def	Def	5,855,299
Colorado & Southern Ry	692	27,181,642	18,619,601		5,362,310	6.84		4,146,545
Denver & Rio Grande Western RR	1,899	112,670,867	77,551,785		17,910,161	6.96		17,516,257
Duluth, Missabe & Iron Range Ry	507	46,212,376	31,137,077		4,816,277	5.31		5,781,679
Duluth, Winnipeg & Pacific Ry	175	13,149,590	9,176,074		2,256,834	21.28		1,811,684
Fort Worth & Denver Ry	1,201	24,099,406	20,022,509	Def	1,584,852	Def	Def	1,743,551
Green Bay & Western RR	255	7,441,192	6,606,181	Def	7,584	Def	Def	14,109
Kansas City Southern Ry	1,672	106,414,911	77,810,222		10,421,376	5.18		7,793,309
Lake Superior & Ishpeming RR	117	5,451,129	5,459,471	Def	74,650	Def	Def	110,945
Missouri-Kansas-Texas RR	2,609	79,968,274	59,415,961	Def	968,417	Def	Def	2,559,819
Missouri Pacific RR	9,901	451,082,347	343,796,894		38,681,455	4.49		16,786,413
Northwestern Pacific RR	321	14,079,696	8,871,775		1,445,197	6.27		2,160,788
Oregon Electric Ry	185	6,310,867	4,142,504		97,894	0.78		405,861
St. Louis-San Francisco Ry	4,728	229,692,901	176,174,569		22,389,569	5.10		14,140,405
St. Louis Southwestern Ry	1,513	153,272,289	116,607,716		30,180,469	9.55		31,826,754
Soo Line RR	4,547	140,651,018	102,409,482		13,808,515	5.56		10,164,282
Southern Pacific Transportation Co.[c]	11,5[illegible]	1,119,329,894	861,599,771		93,118,[illegible]	4.60		[illegible]
Texas & Pacific Ry	2,134	108,412,791	87,820,956		11,894,265	4.79		7,485,381
Toledo, Peoria & Western RR	239	11,411,411	8,621,606		619,910	4.99		610,318
Union Pacific RR	9,481	769,621,333	567,161,927		132,085,597	7.04		122,945,857
Western Pacific RR[e]	1,495	88,314,601	72,176,6 6		5,678,219	3.62		3,579,822
TOTAL WESTERN DISTRICT	118,786	5,325,199,274	4,928,980,174		530,284,556	4.24		454,948,670
TOTAL UNITED STATES	208,747	13,409,815,385	10,556,411,981		827,685,498	*2.96		*391,814,837

*Revised to include final Illinois Central Gulf statistics

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[a] Income after fixed and contingent charges and after extraordinary and prior period items and federal income taxes thereon.

[b] Includes former Gulf, Mobile and Ohio and Illinois Central merged to form Illinois Central Gulf August 10, 1972.

[c] Southern Ry System figures include Class II and switching and terminal companies not included in district total.

[d] Represents Chicago & North Western Railway Company at December 31, 1971 and Chicago & North Western Transportation Company at December 31, 1972.

[e] Includes Sacramento Northern Ry. and Tidewater Southern Ry. Company.

TABLE IV-8

CHARACTERISTICS OF AVERAGE AND MARGINAL RAIL CARRIERS

Net Income (10^3 dollars)	6,220.0
Total Operating Income (10^3 dollars)	212,854.0
Total Expenses (10^3 dollars)	167,562.0
Operating Ratio (%)	78.7

Estimated Impacts of Penalty Rates

Table IV-9 summarizes the impacts of penalty rates on the net profits and operating ratio of the average rail carrier. The table presents the impact of the various penalty rates at two spill levels, the harmful quantity and the maximum container size (60 ton tank car) for the four materials considered. Also included is the change per 1000 pounds of material spilled. This number can be used to readily compute the impacts on the two parameters for any size spill. From the information in these tables, the following conclusions can be drawn.

- Impacts of the penalty rates on the average rail carrier are not nearly as severe as the impacts on the average motor carrier. The maximum liability represents an 8 percent decrease in net profits or an increase in the operating ratio of 0.26 (from 78.7 to 78.96).
- Under the DOHM Methodology, the $500.000 maximum liability is reached for ammonia and chlorine when a 60 ton tank car is lost.
- For the Unit of Measurement and Resource Value Methodologies, the maximum liability is reached for chlorine when a 60 ton tank car is lost.

From the above analysis it appears that the average rail carrier, can sustain a relatively large spill of any one of the materials and still continue to operate; however, closer inspection of the actual distribution of Class I railroads indicates that a substantial percentage (~28%), based on 1973 statistics are operating in the red and hence any penalty

TABLE IV-9

SUMMARY OF FINE IMPACTS ON AVERAGE RAIL CARRIER RESULTING FROM THE SPILLAGE OF SELECTED HAZARDOUS MATERIALS INTO A RIVER

	DOHM			IMCO			Resource Value			Unit of Measurement		
Spilled Material	Spillage of the Harmful Quantity	Spillage of the Maximum Container	Change Per 1000 Pounds Spilled	Spillage of the Harmful Quantity	Spillage of the Maximum Container	Change Per 1000 Pounds Spilled	Spillage of the Harmful Quantity	Spillage of the Maximum Container	Change Per 1000 Pounds Spilled	Spillage of the Harmful Quantity	Spillage of the Maximum Container	Change Per 1000 Pounds Spilled
1. Percentage Decrease in Annual Net Profit												
Anhydrous Ammonia	0.01	1.31	0.01	0.06	8.04	0.08	0.01	2.09	0.02	0.00	1.10	0.01
Chlorine	0.10	0.91	0.01	0.07	8.04	1.06	0.01	8.04	0.59	0.01	8.04	0.13
Caustic Soda	0.07	0.85	0.00	0.07	1.16	0.01	0.01	0.07	0.00	0.01	0.14	0.00
Sulfuric Acid	0.08	0.81	0.00	0.07	1.16	0.01	0.01	0.07	0.00	0.01	0.14	0.00
2. Increase in Operating Ratio												
Anhydrous Ammonia	0.00	0.04	0.00	0.02	0.26	0.02	0.02	0.08	0.02	0.02	0.05	0.02
Chlorine	0.00	0.03	0.00	0.02	0.26	0.05	0.02	0.26	0.04	0.02	0.26	0.03
Caustic Soda	0.00	0.03	0.00	0.02	0.06	0.02	0.02	0.02	0.02	0.02	0.03	0.02
Sulfuric Acid	0.00	0.03	0.00	0.02	0.06	0.02	0.02	0.02	0.02	0.02	0.03	0.02

imposed as the result of a hazardous material spill would only aggravate an already weak business position. The cumulative distribution of Class I railways based on 1973 net income is shown in Figures IV-2 (A-D). These graphs can be used to assess the impacts of various size spills on the industry or industrial carriers under the various methodologies in a manner similar to that discussed for the trucking industry.

It should be noted that these figures represent the bulk of rail carriers whereas the curves for the trucking industry (Figure IV-1) were derived from a representative sample set. This figure indicates approximately 37 percent of the rail carriers would have one year's worth of profits eliminated by a $500,000 maximum liability over and above the 28 percent (of the total) presently operating in the red.

Summary of Impacts on Rail Carriers

Based on 1971 statistics, revenues per ton for Class I and II railroads averaged $8.15/ton.[5] For the average carrier derived in this study, freight rate increases of $0.66 per ton (8 percent) would be required to offset the $500,000 maximum liability assuming one spill of this magnitude per year.

Average potential impacts of penalties on the rail industry are generally not as severe as those on the trucking industry. However, the current profit situation of many 2.5 Class I railroads is much that the threat of imposition any fines for the spillage of hazardous material would most likely have a negative effect in that these operations (30 percent) are not even generating profits which could be used to institute spill prevention measures.

Only 15 percent of all barge transportation in the United States is regulated by the ICC. Moreover, the degree of non-regulation for chemical transportation by large is approximately 97 percent. Of this 97 percent, 60 percent of the non-regulated movement of chemicals is done by for-hire carriers (common and contract); the remainder being carried by industry owned and operated private fleets.[6] Since most barge operations are unregulated, reporting of financial and operating data to the government is not required. Hence, in assessing the economic impacts of spill regulations on barge operators, an approach different from that used for the

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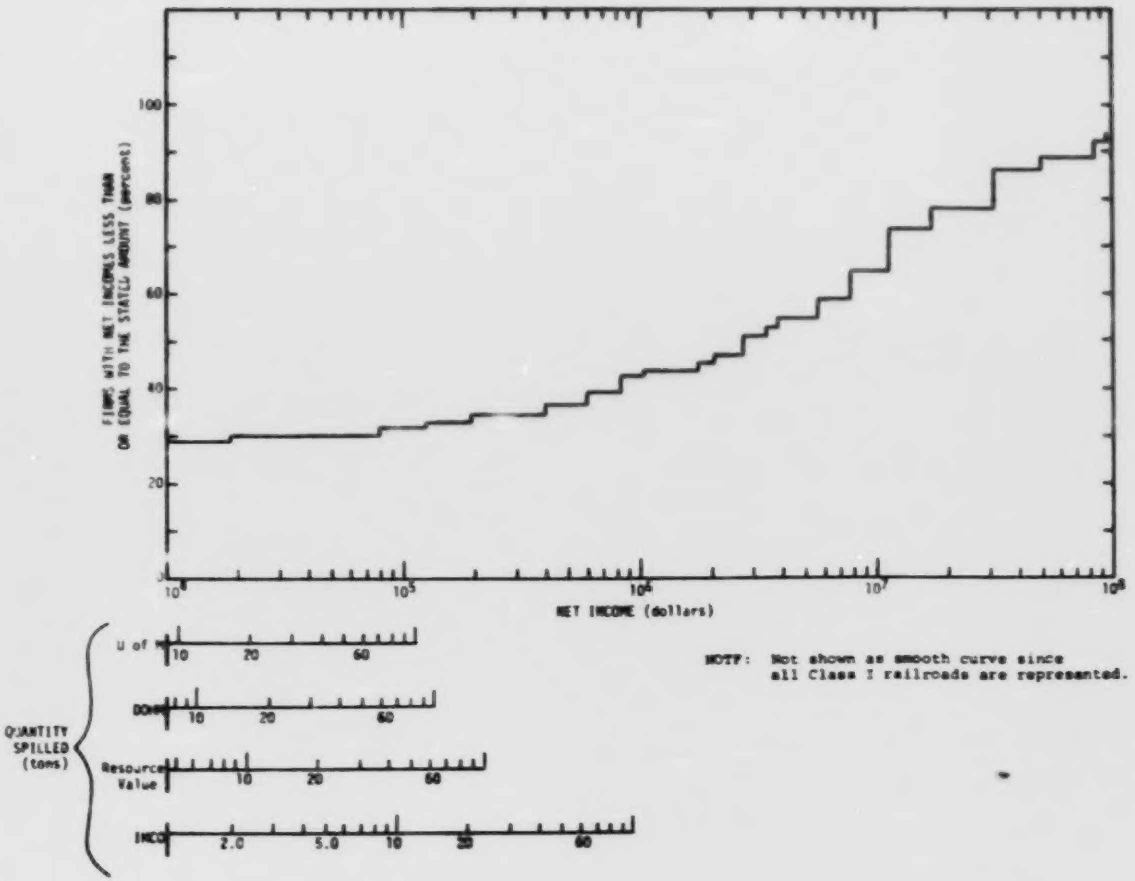
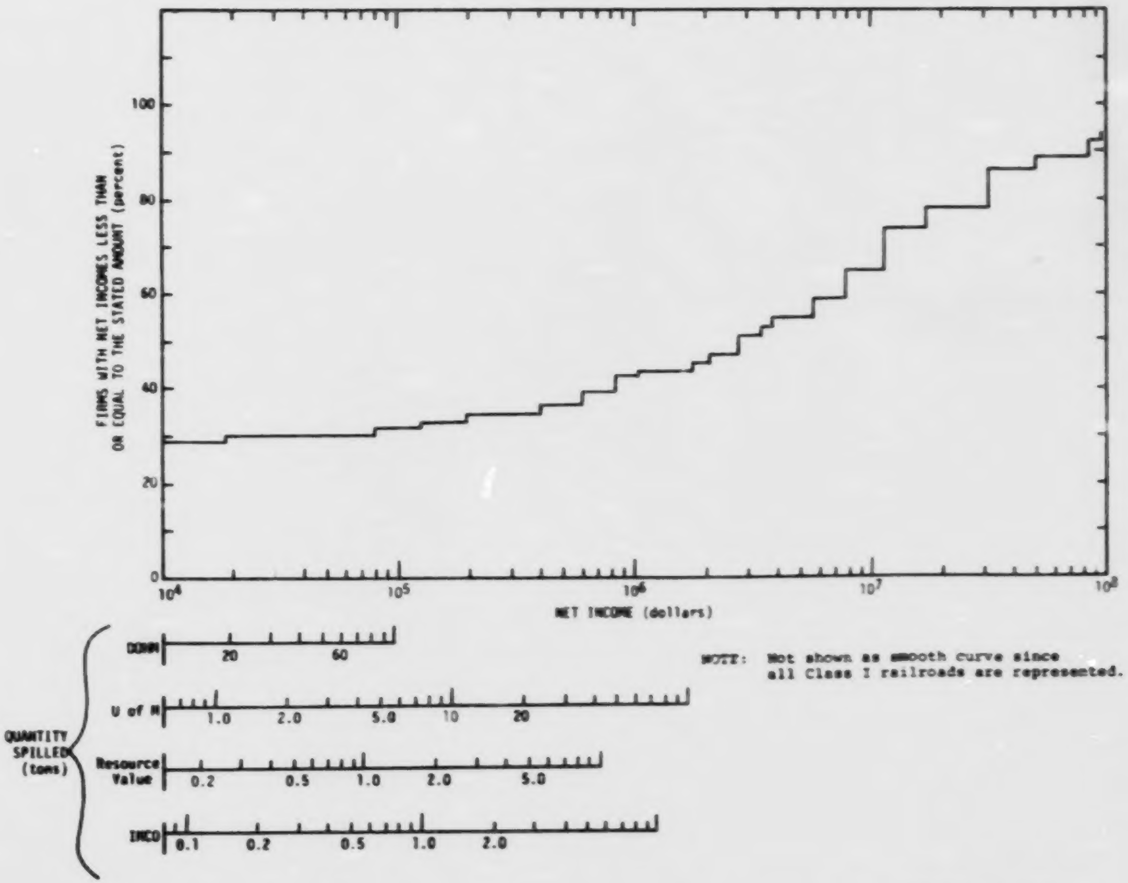
[5] "Statistical Abstracts of the United States," 9th Annual Ed., U. S. Department of Commerce, 1973.

[6] American Waterways Operators, 1972 Inland Waterborne Commerce Statistics (1973).



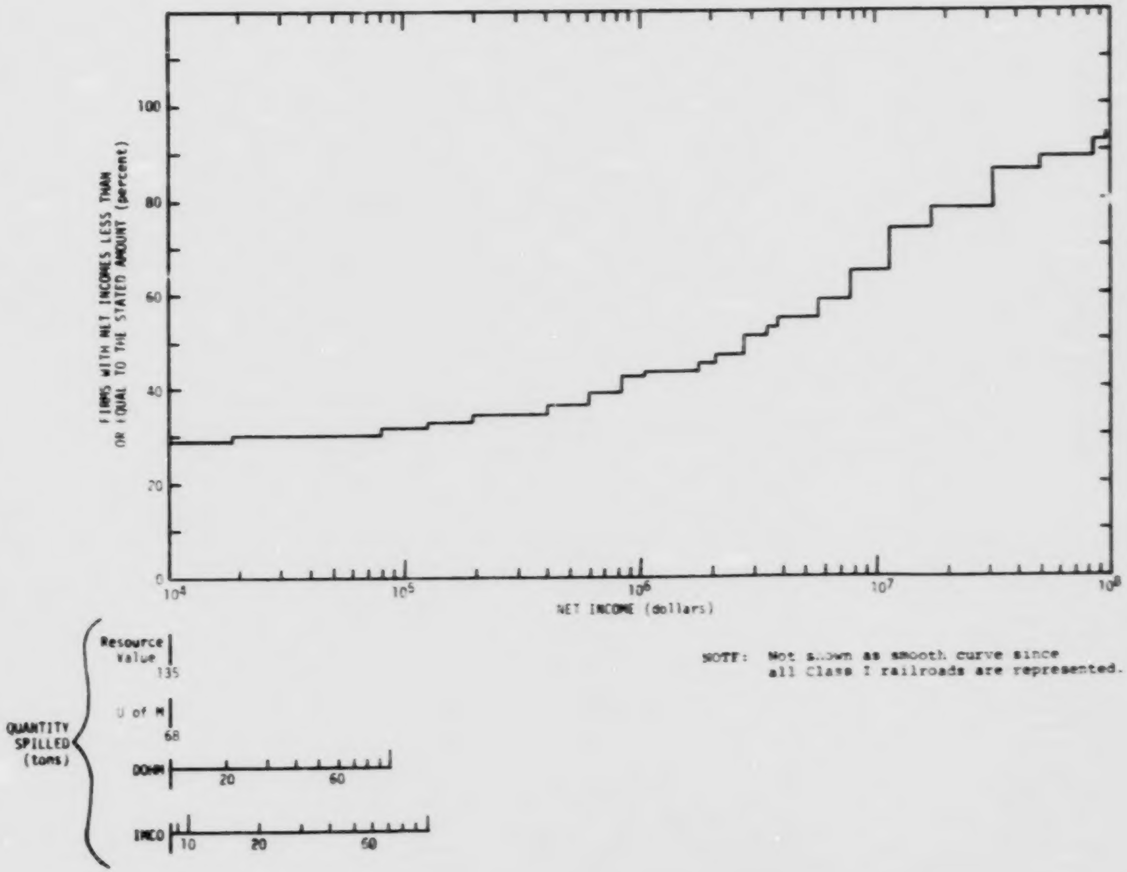
NOTE: Not shown as smooth curve since all Class I railroads are represented.

FIGURE IV-2 (A). POTENTIAL IMPACTS ON NET PROFITS OF RAIL CARRIERS RESULTING FROM THE SPILLAGE OF ANHYDROUS AMMONIA INTO A RIVER



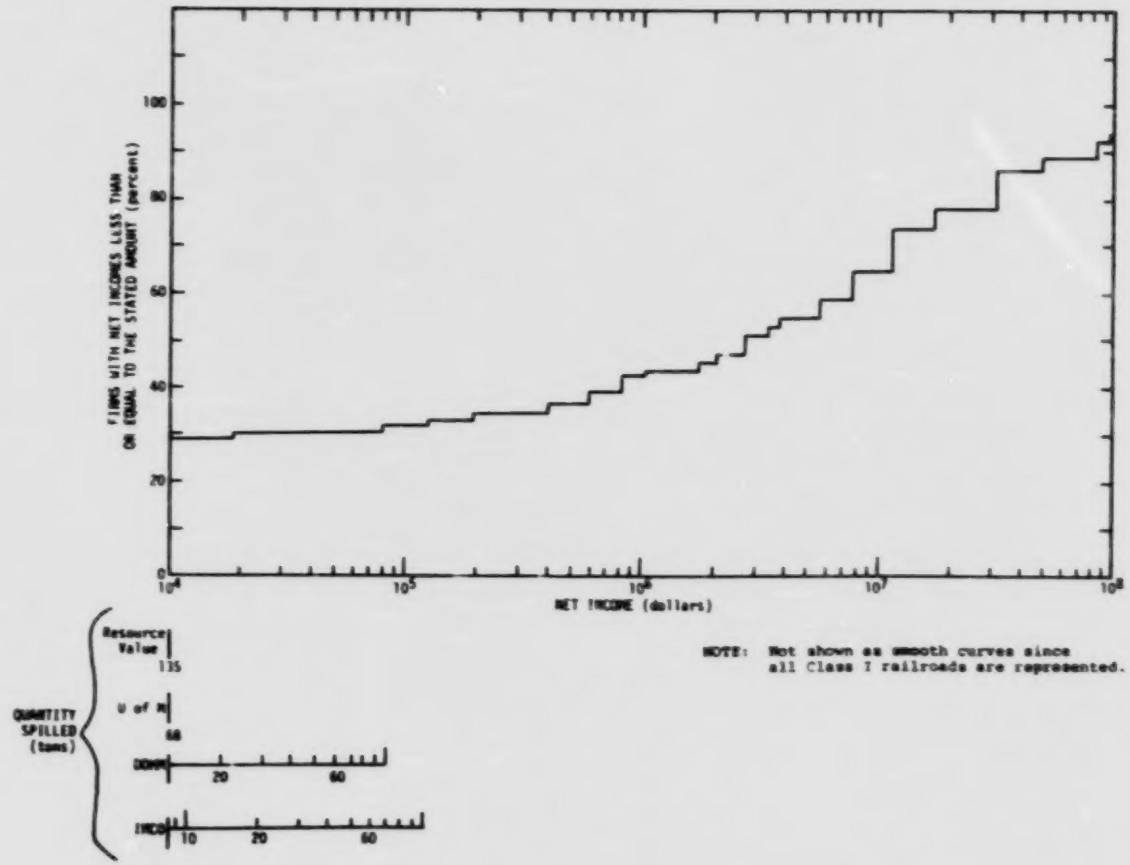
NOTE: Not shown as smooth curve since all Class I railroads are represented.

FIGURE IV-2 (B). POTENTIAL IMPACTS ON NET PROFITS OF RAIL CARRIERS RESULTING FROM THE SPILLAGE OF CHLORINE INTO A RIVER



NOTE: Not shown as smooth curve since all Class I railroads are represented.

FIGURE IV-2 (C). POTENTIAL IMPACTS ON NET PROFITS OF RAIL CARRIERS RESULTING FROM THE SPILLAGE OF CAUSTIC SODA INTO A RIVER



NOTE: Not shown as smooth curves since all Class I railroads are represented.

FIGURE IV-2 (D). POTENTIAL IMPACTS ON NET PROFITS OF RAIL CARRIERS RESULTING FROM THE SPILLAGE OF SULFURIC ACID INTO A RIVER regulated motor-carriers and railways must be employed. Specifically it is necessary to derive by indirect methods an approximate financial and operating profile for barge operations and then use the derived profile as a basis for assessing the impacts of the various proposed penalty rates. This derivation is performed in the next sections.

The Barging Industry

Approximately 1,700 companies[7] are engaged in commercial barge operations on inland waterways of the United States: 113 companies are certificated by the Interstate Commerce Commission (ICC) to provide service as regular route common carriers; 32 companies hold ICC permits to provide services under contract with a shipper; 1,150 companies are engaged in transportation of commodities which are exempt from regulation under provisions of the Interstate Commerce Act; and about 400 companies are engaged in private transportation of their own commodities.

The 1,700 companies operate 14,000 dry cargo barges and scows with total cargo capacity in excess of 14 million tons; 2,600 tank barges with total cargo capacity of approximately 5,150,000 tons; and 3,800 tow boats and tugs with a total aggregate power in excess of 2,700,000 horsepower.[7]

Cost Estimates for Barge Operations

It is customary to estimate operating and fixed costs for barges and tow boats on an hourly basis. In Appendix A, hourly operating costs for barges and tow boats in the lower Mississippi River are estimated. From these estimates transport costs per ton and ton-mile for a representative list of distances and tows is computed. These costs are the basic starting point for deriving operating and financial characteristics for the average barge operator.

Figure IV-3 provides a description of the step-by-step procedures in Appendix A used to derive financial and operating data for the average large operator. The reader is referred to Appendix A for the details of this derivation. Figures derived in this appendix indicate that operating costs for an average large operator are $2,000,000. Assuming an operating ratio of .85 this translates to an operating revenue of $2,325,000. per year leaving an estimated operating income of $325,000. The following analysis of the impacts of the four penalty assessment methods is based on these figures. It should be recongnized that impact analyses based on indirectly generated average data give only a rough

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[7] American Waterways Operators, Inc., Big Load Afloat.

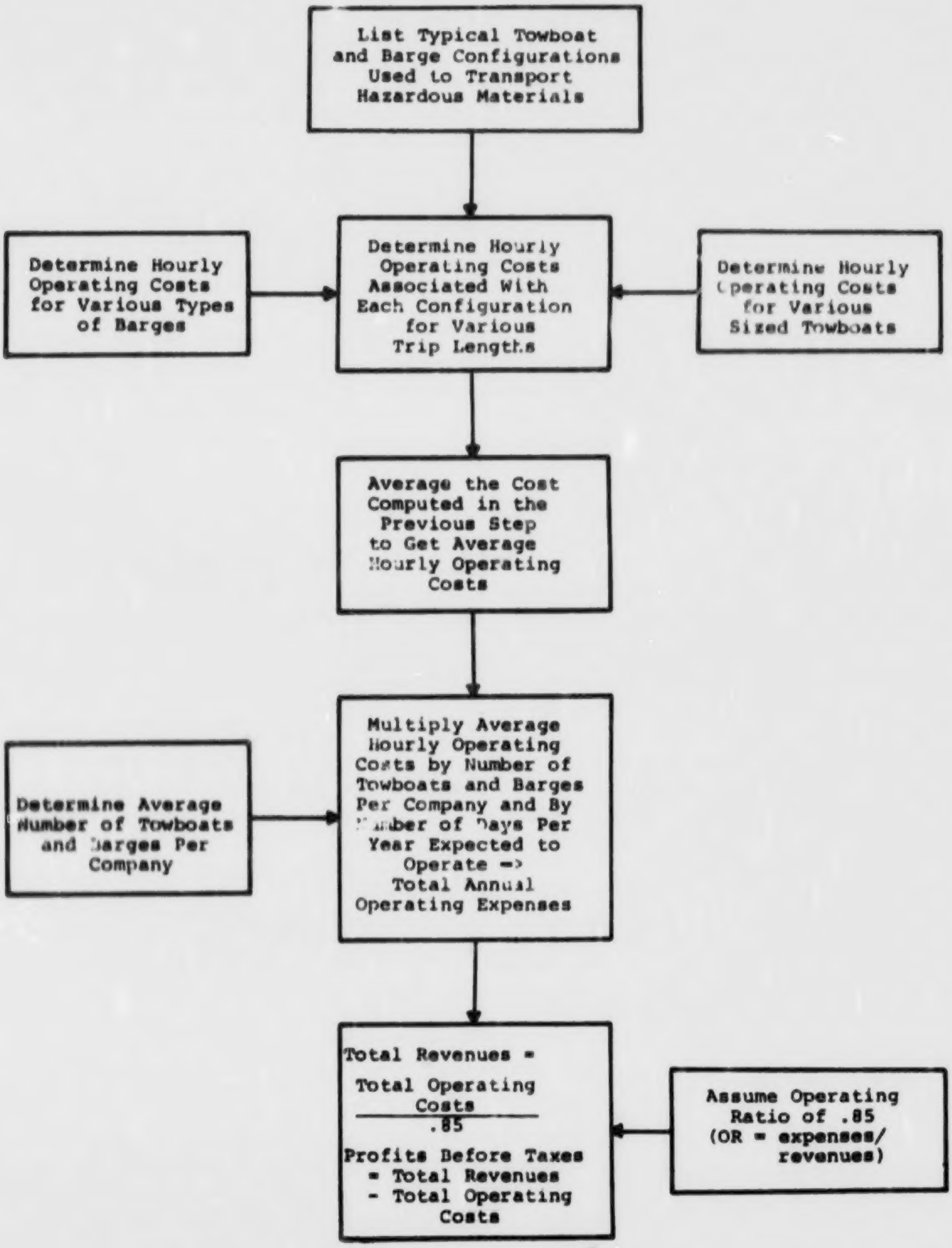
List Typical Towboat and Barge Configurations Used to Transport Hazardous Materials
Determine Hourly Operating Costs for Various Types of Barges
Determine Hourly Operating Costs Associated With Each Configuration for Various Trip Lengths
Determine Hourly Operating Costs for Various Sized Towboats
Average the Cost Computed in the Previous Step to Get Average Hourly Operating Costs
Determine Average Number of Towboats and Barges Per Company
Multiply Average Hourly Operating Costs by Number of Towboats and Barges Per Company and By Number of Days Per Year Expected to Operate => Total Annual Operating Expenses
Total Revenues = Total Operating Costs / .85
Profits Before Taxes = Total Revenues - Total Operating Costs
Assume Operating Ratio of .85 (OR = expenses/ revenues)

FIGURE IV-3. PROCEDURE FOR ESTIMATING LARGE OPERATING COSTS

assessment. However, in the absence of specific operating and financial data for barge operators, derived data is the only available alternative. The impact assessment can be made more precisely when specific company data becomes available.

The only comparison that can be offered at this time between the average income and expense figures derived by the above method and published data sources is the ICC statistics for a total of 177 certified carriers of Class A, B, and C operating in inland and coastal waterways. The total operating revenue for 1971 of these carriers was $435.3 million or an average of $2,459 thousand per certified carrier. Although 97 percent of chemical transportation by water is not regulated by the ICC, it it believed that published data for 177 carriers provides a good sample of the broad spectrum of inland water carrier operations. Therefore, it can be concluded that the average revenue of $2,325 thousand derived in this study is a good representation of an average barge operator's revenue at least in the Mississippi River system.

Impacts of Penalty Rates

Impacts of penalty rates on the average barge operator (as derived above) are summarized in Table IV-10. As with the other modes, impacts are assesed on the basis of net profit and operating ratio for various size spills. Since representative data on the distribution of barge operators is not available it was not possible to determine the size of the marginal operator. However, inspection of Table IV-10 shows that in most instances even the average firm is severely impacted by the loss of a whole barge load of material. For example:

- Under the DOHM and IMCO Methodologies, loss of a single barge load of any one of the four materials results in severe economic impacts.
- Under the Resource Value and Unit of Measurement Methodologies loss of a chlorine or ammonia barge would result in equally severe impacts. However, financial impacts resulting from an equal loss of caustic soda or sulfuric acid would not be severe enough to eliminate annual net profits.
- Penalty rates under the DOHM Methodology are sufficiently high for all chemicals to raise some question as to whether barge operators would be willing to handle these materials.

TABLE IV-10

SUMMARY OF FINE IMPACTS ON THE AVERAGE BARGE OPERATOR RESULTING FROM THE SPILLAGE OF SELECTED HAZARDOUS MATERIALS INTO A RIVER

	DOHM			IMCO			Resource Value			Unit of Measurement		
Spilled Material	Spillage of the Harmful Quantity	Spillage of the Maximum Container	Change Per 1000 Pounds Spilled	Spillage of the Harmful Quantity	Spillage of the Maximum Container	Change Per 1000 Pounds Spilled	Spillage of the Harmful Quantity	Spillage of the Maximum Container	Change Per 1000 Pounds Spilled	Spillage of the Harmful Quantity	Spillage of the Maximum Container	Change Per 1000 Pounds Spilled
1. Percentage Decrease in Annual Net Profit												
Anhydrous Ammonia	0.94	1538.46	2.85	1.09	1538 46	1.44	0.15	767.33	0.33	0.09	403.74	0.18
Chlorine	0.02	1538.46	1.96	1.40	1538.46	20.30	0.15	1538.46	11.34	0.13	1539.46	2.58
Caustic Soda	17.72	1538.46	1.85	1.41	425.75	0.19	0.15	26.35	0.01	0.11	51.91	0.02
Sulfuric Acid	21.07	1538.46	1.77	1.41	425.75	0.19	0.18	25.45	0.01	0.11	51.91	0.02
2. Increase in Operating Ratio												
Anhydrous Ammonia	0.15	215.08	0.42	0.17	215.08	0.22	0.04	107.28	0.07	0.03	56.46	0.05
Chlorine	0.02	215.08	0.30	0.22	215.08	2.86	0.04	215.08	1.61	0.04	215.08	0.02
Caustic Soda	2.50	215.08	0.28	0.22	59.54	0.05	0.04	3.71	0.02	0.04	7.28	0.02
Sulfuric Acid	2.97	215.08	0.27	0.22	59.54	0.05	0.05	3.50	0.02	0.04	7.28	0.02

- Penalty rates for chlorine are quite high under all four methodologies so that even small spills of this material could result in rather severe financial impacts on the barge operators.

- In addition to these impacts, the barge operator must also pay for the product loss incurred.

Since financial and operating statistics are not available for the majority of barge operators, it is not possible to determine the percentage of the industry severely impacted by various penalty rates. In light of the potential $5,000,000 maximum liability and the large quantities handled, it is likely that a majority of the operators would face severe financial impacts under any of the four penalty schedules. For example, the loss of a 1150 ton barge would result in the maximum fine of $5 million for any material with a rate of penalty equal to or exceeding $2.17 per pound. Average net profits ($325,000 per year) would be eliminated with the loss of the 1150 ton barge for any material with a rate of penalty exceeding $0.14 per pound.

Summary of Impacts on Barge Operators

Impacts of the penalty rates under the four methodologies on the average barge operator range from moderate to extreme severity for barge spills. Although financial and operating data on barge operators are generally unavailable, it is doubtful that any operators are large enough to absorb a 5 million dollar penalty. Even the American Commercial Barge Line Co., the largest regulated carrier for 1971 in terms of revenue operating in the Mississippi and tributaries with total revenue of $42 million and net income of $1.5 million cannot bear a penalty level of $5 million. The regulated carrier who had the highest net income for 1971 ($3.5 million) in the Mississippi and Tributaries Area (Ohio Barge Lines, Inc.) would record a loss of $1.5 million for its yearly operations if faced with the maximum liability.

REFERENCES

1. Federal Register, Vol. 39, No. 164, Part IV, August 22, 1974.

2. U. S. Department of Transportation, Transportation Projections 1970-1980, July, 1971.

3. Full year 1971-1970 Report of the American Trucking Association, Inc.

4. 1974 Yearbook of Facts, American Association of Railroads, AAR, Washington, DC, February 1974.

5. "Statistical Abstracts of the United States," 9th Annual Ed., U. S. Department of Commerce, 1973.

6. American Waterways Operators, 1972 Inland Waterborne Commerce Statistics, (1973).

7. "Big Load Afloat," American Waterways Operators, Inc.

V. ENVIRONMENTAL IMPACTS

INTRODUCTION

While it is generally accepted that environmental damage is one of the major impacts of hazardous material spills, few data are available to quantify these impacts. Moreover, no estimates have been made of the national impact of these spills. Consequently, the following attempt to measure the differential environmental impact of alternative approaches for establishing harmful quantities and rates of penalty will deal with relative measures rather than absolute ones. Before exploring the nuances of such an undertaking, however, it is instructive to discuss briefly those few incidents for which environmental impacts have been quantified on the national impact level.

The Public Health Service and, more recently, the Federal Water Quality Administration and the Environmental Protection Agency have reported data on pollution caused fish kills in the United States.[1-11] Some of the pertinent historical information is presented in Tables V-1 and V-2. In general, the trend has been towards greater numbers of fish affected, (an increase of 257 percent) a manifestation of both an increase in incidents, and a more efficient reporting process. The former factor is the dominant of the two. Similarly, the total acreage of lakes and reservoirs affected has increased substantially over the reporting period (2257 percent). Total river miles affected, however, have displayed a much slower rate of growth (55 percent). The breakdown between game and non-game species varies greatly from year to year. Table V-2 shows the nature of sources of spills for 1970. It is clear from this data that stationary sources are far and away the most impactive. This suggests

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[1] "Pollution-Caused Fish Kills in 1960," U. S. Department of Health, Education, and Welfare; Public Health Service, 1960.

[2] "Pollution-Caused Fish Kills January-September 1961," U. S. Department of Health, Education, and Welfare; Public Health Service, Washington, DC, November 1961.

[3] "Report of Pollution-Caused Fish Kills, January-June 1962," U. S. Department of Health, Education, and Welfare; Public Health Service, Washington, DC, September 1962.

[4] "Pollution-Caused Fish Kills in 1963," U. S. Department of Health, Education, and Welfare; Public Health Service, Washington, DC, 1964.

[5] "Pollution-Caused Fish Kills in 1964," U. S. Department of Health, Education, and Welfare; Public Health Service, Washington, DC, 1964.

[6] "Pollution-Caused Fish Kills in 1965," U. S. Department of the Interior, Federal Water Pollution Control Administration, Washington, DC, 1965.

TABLE V-1

HISTORICAL FISH KILL DATA REPORTED FOR THE U. S.[1-11]

Year	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Number of States Reporting	38.00	45.00	37.00	38.00	40.00	44.00	46.00	40.00	42.00	45.00	45.00
Total Estimated Fish Kill	6,379,000.00	15,910,000.00	7,118,000.00	7,860,000.00	18,387,000.00	11,784,000.00	9,115,000.00	11,531,030.00	15,236,000.00	41,004,000.00	22,760,820.00
Reported Kills From Sources of Potential Chemical Spills				3,[illegible]95,817.00	(>6,000,000.00 of Commercial Value)	4,864,953.00	6,356,035.00	9,212,298.00	8,000,744.00	39,245,417.00	16,700,441.00
Average Duration of Fill in Days	2.95	2.64	2.59	3.18	2.44	2.57	2.71	3.34	2.99	3.11	3.25
For Reports Where Extent of Damage Was Reported											
River											
Number of Reports	109.	240.	259.	271.	339.	292.	251.	219.	264.	356.	487.
Miles of Stream	1,204.00	1,696.00	1,448.00	2,203.00	1,440.00	1,300.00	989.00	1,039.00	1,565.00	2,358.00	1,865.00
Lakes and Reservoirs											
Number of Reports	25.	50.	25.	49.	57.	38.	46.	33.	37.	98.	111.
Acres Affected	1,487.00	5,907.00	2,581.00	5,644.00	12,637.00	4,630.00	21,504.00	1,996.00	2,400.00	6,068.00	33,168.00

TABLE V-2

NATURE OF KILLS REPORTED IN 1970[11]

Source	Game Fish Killed	Non-Game Fish Killed
Agricultural Pesticides and Fertilizers	264,391	1,149,472
Swimming Pools (Hypochlorite-Chlorine Spills)	73	1,763
Industrial	3,250,252	6,569,241
Transportation	284,782	3,616,348
Other	177,409	305,996

that if differential harmful quantities or rates of penalty are to be employed, those for stationary sources should be more restrictive.

Few spill incidents have received any form of environmental damage assessment.* Those which have, include the Clinch River Fish Kill, an ethyl benzene-creosote spill into the Roanoke River, and the deliberate poisoning of Pond Lick Reservoir in Ohio. A brief synopsis of each of these incidents is included on the following page.

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*It should be noted that the EPA has now published a field detection and damage assessment manual designed for this purpose.[12]

[7] "Fish Kills by Pollution in 1966," U. S. Department of the Interior, Federal Water Pollution Control Administration, Washington, DC, 1966.

[8] "Pollution-Caused Fish Kills in 1968," U. S. Department of the Interior, Federal Water Pollution Control Administration, Washington, DC, 1967.

[9] "Pollution-Caused Fish Kills in 1968," U. S. Department of the Interior, Federal Water Pollution Control Administration, Washington, DC, 1968.

[10] "1969 Fish Kills Caused by Pollution," Federal Water Quality Administration, USGPO, Washington, DC, 1970.

[11] "Fish Kills Caused by Pollution in 1970," U. S. Environmental Protection Agency, USGPO, Washington, DC, 1972.

[12] Field Detection and Damage Assessment Manual for Oil and Hazardous Material Spills, Environmental Protection Agency, Washington, DC, June 1972.

Clinch River. In 1967, a fly ash holding pond dike maintained by the Appalachian Power Company's 700-megawatt steam power generating plant near Carbo, Virginia, collapsed discharging 130 million gallons into Dumps Creek which joins the Clinch River 0.5 miles downstream. The caustic plug equalled 40 percent of the existing flow. The pond waters had an estimated pH of 12-12.7 compared to 8-8.5 in the naturally alkaline receiving waters. The plug proceeded downstream for 4.5 days at a speed of 0.85 miles an hour killing virtually all of the fish in its path. During that time, 216,000 sport and rough fish died in a 90 mile stretch of the river through Virginia and Tennessee. The plug finally became diluted to a level where it was no longer severely toxic. Damage assessment studies revealed that in addition to the fish, bottom dwelling fish food organisms were completely eliminated in the 3-4 mile stretch immediately below the spill site and were drastically reduced in the succeeding 77 miles. Snails and mussels were eliminated in the first 11.5 miles. A follow up study two years after the event revealed that while bottom fauna had recovered considerably, and benthic organisms were returning in significant numbers, the molluscs once abundant in the area had yet to reestablish themselves. Different species of minnows and darters had recolonized the area, but were at lower density levels than those noted upstream of the spill.[12]

Roanoke River. On October 10, 1970, a primary storage tank operated by the Koppers Company in Salem, Virginia, released approximately 2000 gallons of ethylbenzene mixed with creosote into an open cooling water ditch. Some 400-600 gallons of that total reached the Roanoke River which, at the time, was flowing at approximately 42 cfs. This resulted in a concentration of 1000 ppm at the point of discharge. A fish kill followed resulting in the death of a total of 7,979 rough fish and 5,302 sport fish. It was estimated that biological damage extended seven miles downstream. Recovery studies conducted six months after the spill revealed that the major effect had been a decrease in the density and diversity of aquatic life for approximately three miles below the plant outfall. An apparent differential response in fish life left a viable population of minnows while all other major species were eliminated. Bottom fauna was eliminated, but mayflies and stoneflies were staging a comeback at the time of the study.[13]

Pond Lick. On June 2, 1971, approximately 1.5 pounds of endrin solution mixed with strychnine treated corn in a one gallon plastic container was purposely dumped into Pond Lick Reservoir near Portsmouth, Ohio. The effects on the aquatic life in the nearly 50 acre-feet impoundment were disastrous. All life was destroyed except for tadpoles which are resistent to this type of pesticide. Because of endrin's known persistence, no attempt was made to allow the lake to restore itself naturally. Rather, it was determined that positive action should be taken. Consequently, water from the lake was pumped through activated carbon to remove dissolved contaminant while the bottom sediments were scraped off and buried to eliminate all residual endrin. Three months later the lake was restocked for recreational use.

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[13] Cairns, J. Jr., K. L. Dickson and J. S. Crassman. "The Response of Aquatic Communities to Spills of Hazardous Materials," Proceedings of the 1972 National Conference on Control of Hazardous Material Spills, Houston, TX, March 21-23, 1972.

While the destruction of aquatic life noted in these three events is the most common form of damage observed during spill incidences, it is by no means the only environmental effect resulting from spills. Spills may also impair the recreational and aesthetic value of waters. The flushing of acetic acid wastes from a plant in Pennsylvania forces swimmers from the water downstream as a result of excessive odor and a burning sensation in and around the eyes.[14] Further, the threat to species other than aquatic life has been demonstrated on numerous occasions. A spill of acetone-cyanohydrin at Dunreith, Indiana led to the poisoning of several head of livestock, and posed a public health hazard to a downstream municipal water intake.[15] Similarly, aniline spilled from a train wreck in Texas caused the hospitilization of several private citizens after inhalation of toxic vapors. Extensive loss of vegetation, fish kill, and the blinding of several head of cattle was reported in Arkansas when an ammonia pipeline broke in a remote area.[16] Finally, many spills are accompanied by a general reduction of amenities. This reduction may result from the appearance of dead fish at the water surface and along shorelines, or it may stem directly from the presence of odors, discoloration, turbidity, sludges, or slicks which can accompany or precede fish kills.

From this brief account of documented impacts, it is clear that hazardous material spills can have a large and varied impact on the environment. As noted earlier, it is possible to characterize the relative effects that each methodology might have, and in so doing develop a sense of the relative benefit to be gained through implementation. Pursuant to this, it is first necessary to establish the manner in which the alternatives themselves can exert an environmental impact.

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[14] Minutes of Pennsylvania Sanitary Water Board, Vol. 46-10, p. 01.3, October 16, 1968.

[15] Moore, S. L. and S. R. Kin. "Cyanide Pollution and Emergency Duty Train Wreck, Dunreith, Indiana, January 1961," Division of Sanitary Engineering, Indiana State Board of Health, January 1965.

[16] OHM-SIRS File, Environmental Protection Agency, Washington, DC.

FEATURES OF ALTERNATIVE APPROACHES WHICH MAY EXERT AN ENVIRONMENTAL IMPACT

If it is assumed that some spills now occuring can be prevented or these effects reduced, the technical alternatives developed will have an environmental impact in so much as they provide incentive for subsequent action which may change the number and/or severity of spills and provides for emergency response, damage mitigation, and clean-up. Positive incentive will result either from the harmful quantities designated or the rates of penalties established by each approach. Any impact analysis, therefore, must look at the potential effects of each of these factors.

Harmful Quantity

The relative size of harmful quantity is most likely to impact the environment through subsequent responses which would reduce the severity of spills that occur. This may occur via either of two mechanisms: 1) moves by industry to reduce the potential size of spills and 2) more rapid reporting and response. The former of the two reflects the practical reality that harmful quantities in addition to being a self-reporting threshold, are also likely to function as an acceptable spill level. That is, spills of less than a harmful quantity are likely to go unreported and consequently may receive much less attention from industrial management since first party reporting is not required, and therefore, discharges can feel relatively safe from penalty assessment. This provides incentive to reduce the size of potential spills below the harmful quantity level and thereby minimize incidences where reporting is necessitated. These objectives could be accomplished with smaller storage tanks, limited holding pond capacity, modified operating procedures, or other devices.

The second mechanism, more rapid reporting, bears directly on the severity of impacts resulting from spills. Since rapid notification of spills with volumes greater than the harmful quantity is required, response mechanisms are likely to be energized more quickly than they presently are and consequently whatever prospects there are for amelioration will be minimized. Therefore, small harmful quantities will influence rapid reporting for more spills. Because of other provisions in the law, money will also be made available to finance clean-up mitigation should the responsible party not be able to accomplish this himself.

In both cases, however, there are other considerations which may minimize the extent to which these mechanisms will have effects. In the first case, the considerations are, for the most part, economic ones. For potential spill sources, economics of size and process factors will take precedence in determining the dimensions of facilities. The authors feel that the existence of harmful quantity thresholds are not likely to be an active determinant except in the form of minor process modifications and tighter operating procedures. The second mechanism, rapid reporting, is more likely to have a favorable environmental impact. The level of both these effects, however, is very difficult to estimate. Therefore, rather than attempt to quantify the impact, it appears more appropriate to illustrate where the harmful quantity derived by each approach falls on the distribution of spills. Such an approach will at least show how much spillage is likely to be reported.

To perform the latter analysis, it is first necessary to develop the characteristic relation between spill frequency and spill size. Very little data have been published in this area. The most comprehensive information available is that compiled by Factory Mutual Research, Inc.[17] in a recent study for the Environmental Protection Agency. In this study the data from 1500 spill reports, during the period 1969-1974, were analyzed. Portions of the data collected during this study were used to construct spill size vs frequency curves (Figures V-1 thru V-5) for the representative substances. No spills of parathion were reported. Similarly, only one spill of chlorine was reported with a known release quantity. Consequently, relations for these materials are not included. Data for benzene, xylene, and toluene were combined under the general heading BTX materials. Harmful quantities, as designated by each methodology, are also shown in the Figures V-1 thru V-5.

Figure V-1 contains the relation for sulfuric acid which is based on 105 spills (into all environments) of known size. There is little variation between methodologies in harmful quantities for rivers and lakes with respect to the fraction of spills that would or would not be reported. [The total span in harmful quantities from low (Unit of Measurement Methodology) to the high (Resource Value Methodology) encompasses 12 percent of total spills.] This figure further indicates that an average of 40 percent of all sulfuric acid spills in freshwater will be reported under any of the four methodologies. In this respect the differential impact between methodologies is minimal. The same is true with respect to estuaries, except for the DOHM Methodology. In this case, the DOHM harmful quantity is significantly larger than those for the other approaches. Similarly, the harmful quantities for coastal waters are tightly grouped except for the Unit of Measurement Methodology

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[17] Buckley, J. L. and S. A. Weiner -- data collected during conduct of Contract No. 68-03-0317 -- "Historical Documentation of Hazardous Material Spills," transmitted November 1974.

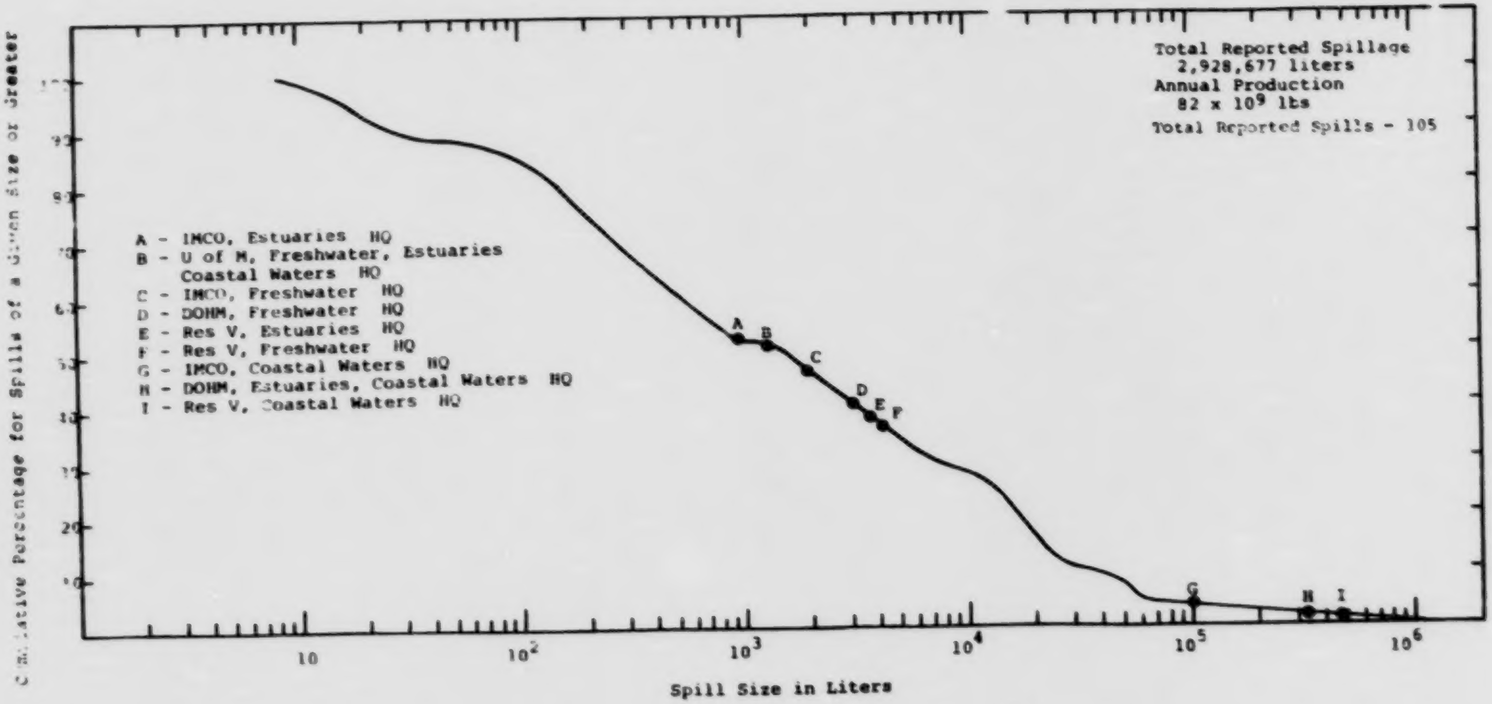

FIGURE V-1. PROFILE OF SULFURIC ACID SPILLS
DATA TAKEN FROM REFERENCE 16.

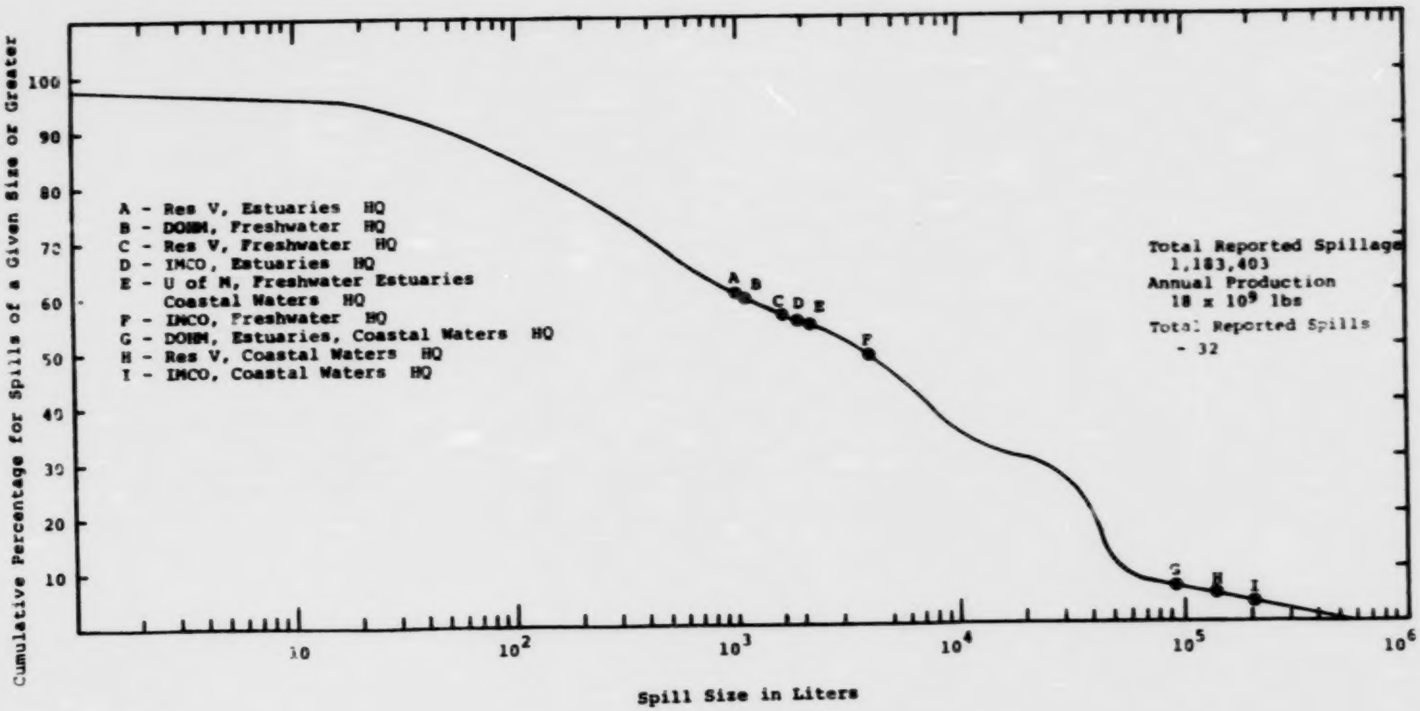

FIGURE V-2. PROFILE OF BENZENE - TOLUENE - XYLENE (BTX) SPILLS DATA TAKEN FROM REFERENCE 16.

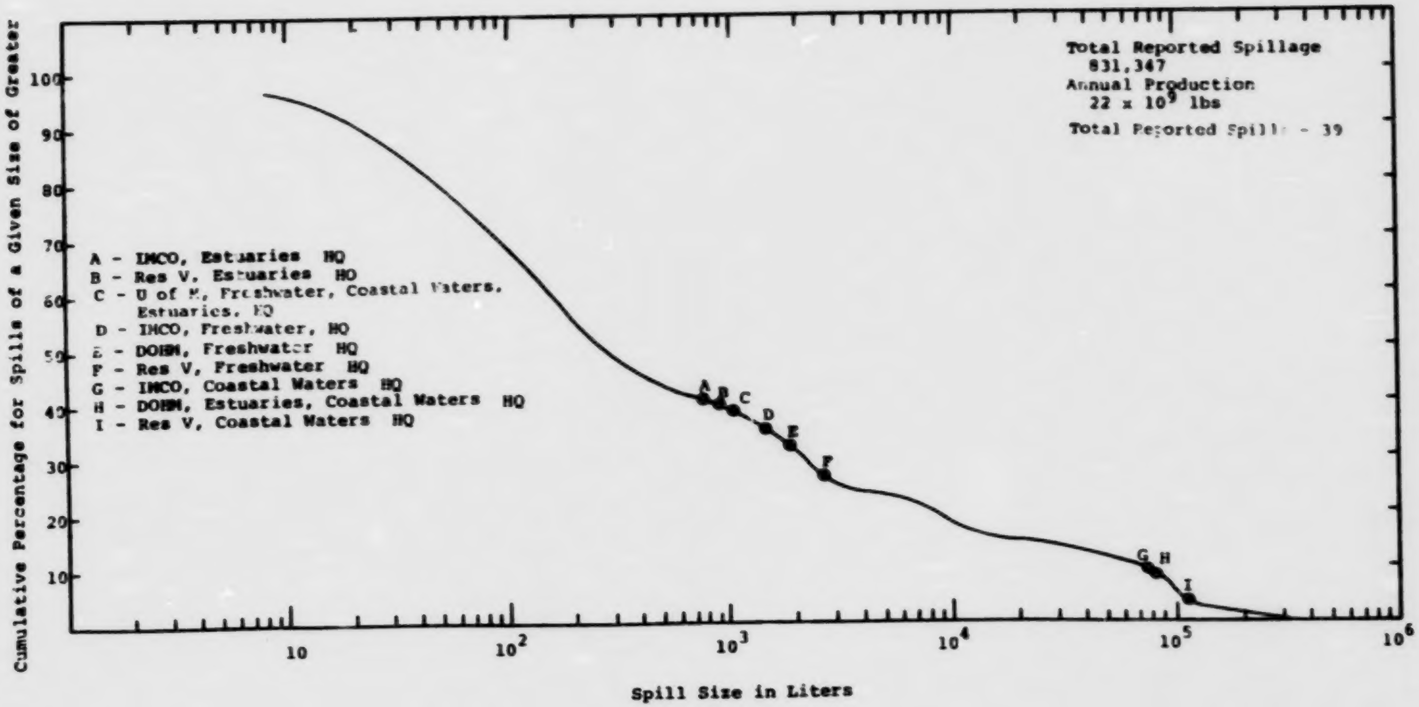

FIGURE V-[illegible]. PROFILE OF CAUSTIC SODA SPILLS
DATA TAKEN FROM REFERENCE 16.

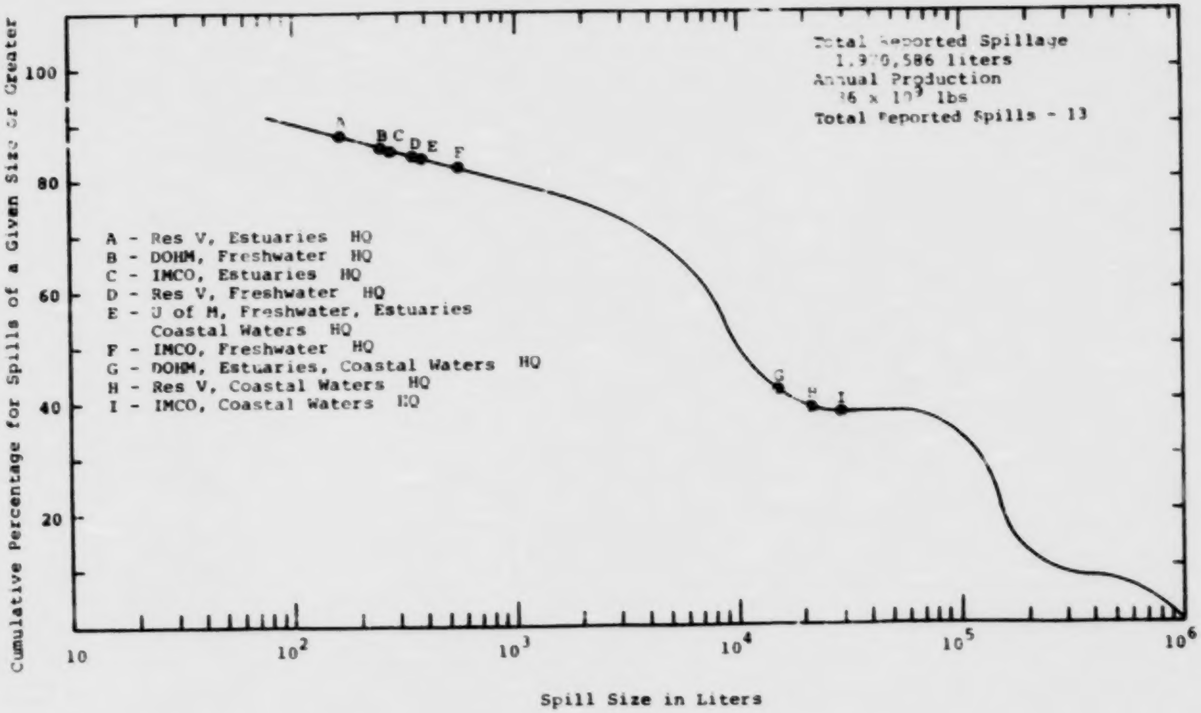

FIGURE V-4. PROFILE FOR AMMONIA SPILLS DATA TAKFN FROM RFFFRENCE 16.

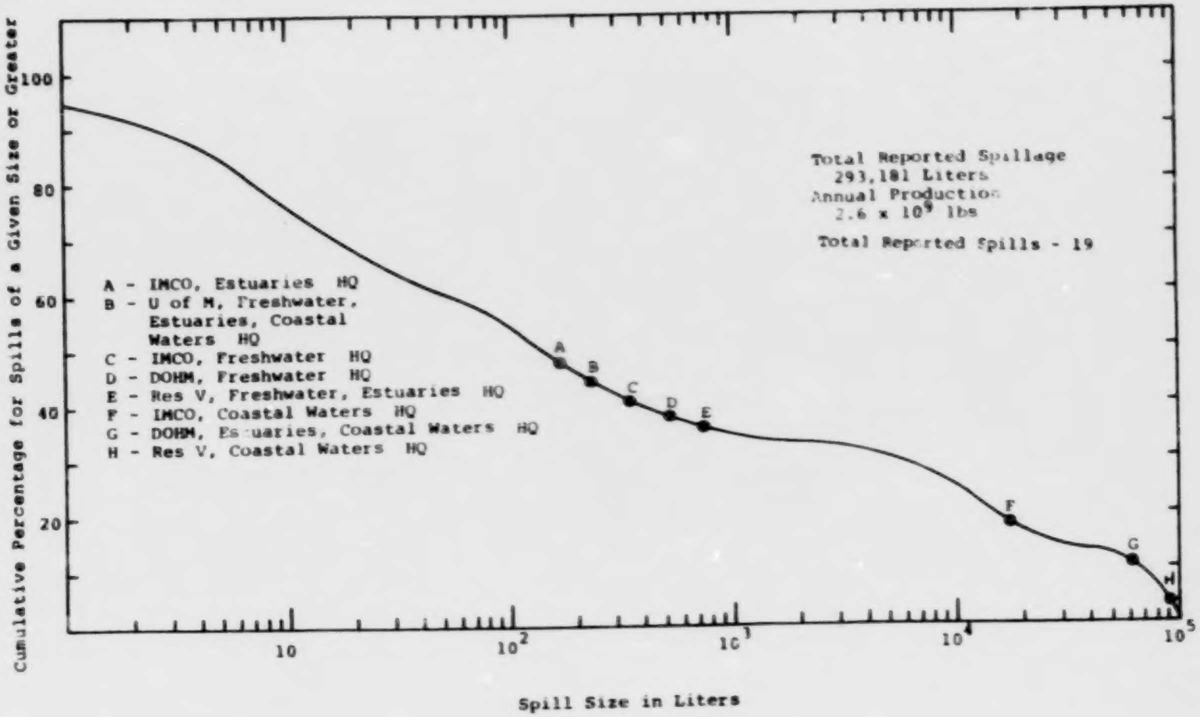

FIGURE V-5. PROFILE FOR PHENOL SPILLS
DATA TAKEN FROM REFERENCE 16.

which is significantly smaller. In this case, however, the difference in size will be of less importance since coastal water shipments are such a small portion of total sulfuric acid movements. Therefore, in terms of environmental impact, the IMCO, Unit of Measurement, and Resource Value approaches are preferred with regard to sulfuric acid, because they will result in the reporting of more spills.

Data has been reviewed from the OHM-SIRS files to estimate the number of spills into water occuring annually. From this data, there were 21 spills of sulfuric acid in 1974.[18] Thus, it appears from Figure V-1 that an average of 8.4 spills (40 percent of oil spills) in excess of the harmful quantity will occur in a year.

The characteristic spill profile for combined benzene, toluene, and xylene (BTX) is presented in Figure V-2 and represents data from 32 reported spills. Once again, there is little difference for the freshwater harmful quantities, with the total span covering only ten percent of total spills.

As in the case of sulfuric acid, the DOHM estuary value is extremely high, and the Unit of Measurement coastal water value is quite low in comparison to other approaches. Since most BTX materials are used as raw materials, shipments are short, interplant transfers. Therefore, coastal water spills are once again of very low probability and the deviation of the Unit of Measurement harmful quantity is considered insignificant. Hence, the IMCO, Resource Value, and Unit of Measurement approaches are considered to have an equal environmental impact, while the DOHM approach will allow significantly more unreported damage to occur in estuaries. On the average, harmful quantities designated by the three preferred approaches will lead to the reporting of nearly 50 percent of all BTX spills. There were 20 BTX spills reported in 1974,[18] and therefore approximately 10 spills in excess of harmful quantities can be anticipated per year.

The characteristic spill relation derived from 39 spills of caustic soda appears in Figure V-3. As with the first two materials, the freshwater harmful quantities for caustic soda are tightly grouped with a total span that covers only eight percent of total spills. The DOHM estuary value remains high and the Unit of Measurement coastal water value remains low.

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[18] Personal Communication with Dr. A. L. Jennings, Hazardous and Toxic Substance Branch, U. S. EPA, Data developed from OHM-SIRS files 1974, transmitted March 7, 1975.*

*The OHM-SIRS files are presently based on voluntary reports submitted to EPA or USCG and do not necessarily indicate the actual magnitude of the problem.

Coastal water shipments of caustic do occur and, therefore, the Unit of Measurement Methodology is the preferred approach while the IMCO and Resource Value Methodologies are given an intermediate status. Approximately 30 percent of all spills will be reported under the porposed methodologies. Since there were 12 reported spills in 1974,[18] this is comparable to an average of 3.6 spills in excess of the harmful quantity per year.

Reported data from 13 ammonia spills is profiled in Figure V-4. Freshwater harmful quantities show no significant difference, with a total spread of only four percent of total spills. Estuary harmful quantities are similarly bunched with the exception of that for the DOHM Methodology. For coastal waters, the Unit of Measurement approach once again stands apart in its tendency to reduce environmental impact. For all but coastal waters, 80 percent of all spills will be reported with institution of any of the four approaches. This indicates mandatory reporting of 12.8 of the 16 ammonia spills reported for 1974.[18]

Data from 19 reported phenol spills is presented in Figure V-5. The same pattern between approaches as noted in earlier profiles is evident here. The difference in freshwater harmful quantities is small, having a total spread of six percent of total spills. The DOHM estuarine harmful quantity remains much higher than the tight group formed by those for the remaining approaches. The Unit of Measurement coastal water value remains much lower. Excluding coastal waters, the approaches will result in the reporting of approximately 40 percent of all spills which is equivalent to 6.4 of the 16 spills reported in 1974.[18]

The profiles presented here can also be analyzed with respect to volume of spills as a percentage of total volume spilled per year. These regulations are presented in Figures V-6 thru V-10. The observations made concerning the relative converage provided by methodologies are well born out. There are no significant differences between freshwater harmful quantities. In fact, in terms of the fraction of total spillage coverage by freshwater harmful quantities, the differences are of a much smaller magnitude than those measured for total spill events. The DOHM estuarine values remain significantly high for all materials but ammonia, where the volume difference is less than three percent. Similarly, Unit of Measurement coastal water harmful quantities are significantly lower than those for other approaches except in the case of ammonia where the incremental difference is only four percent of total spillage. It is interesting to note that for sulfuric acid, BTX, caustic soda, and phenol, the harmful quantities of most approaches occur near the shoulder of the curve where spill volumes become a significant portion of total spillage. Occuring here, the harmful quantities promise to mandate reporting on spills representing better

TABLE V-3

SUMMARY OF ENVIRONMENTAL IMPACT IMPLICATIONS FOR HARMFUL QUANTITIES

Material	Percent of Spills Reported By Preferred Approaches *	Number of Spills Reported Per Year (Preferred Approach)*	Percent of Volume Spilled Reported By Preferred Approaches*	Amount of Material Spilled Reported Per Year (Preferred Approach)*
Sulfuric Acid	40	4.0	99	2,050,000 lbs
BTX	50	3.6	99	450,000 lbs
Caustic Soda	30	1.8	99	550,000 lbs
Ammonia	80	7.0	99	900,000 lbs
Phenol	40	1.7	99	65,000 lbs

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*Preferred approaches are Unit of Measurement, and Resource Value and IMCO excluding coastal water values.

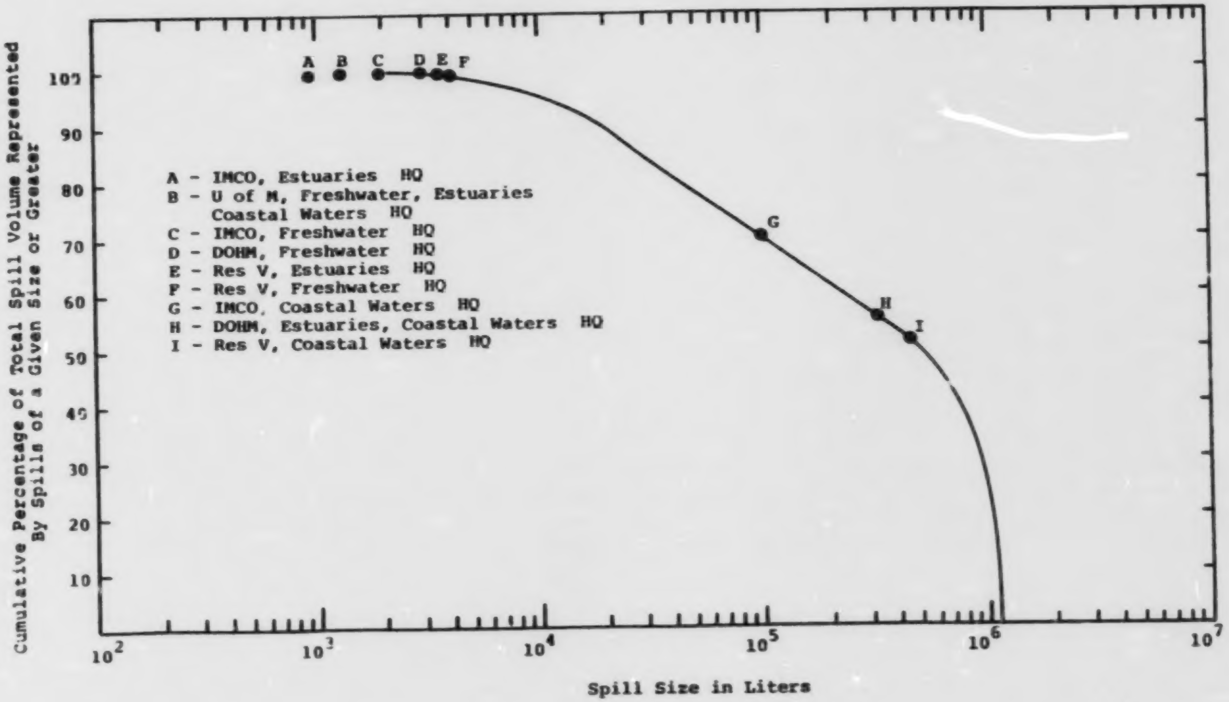

FIGURE V-6. VOLUME PROFILE FOR SULFURIC ACID SPILLS

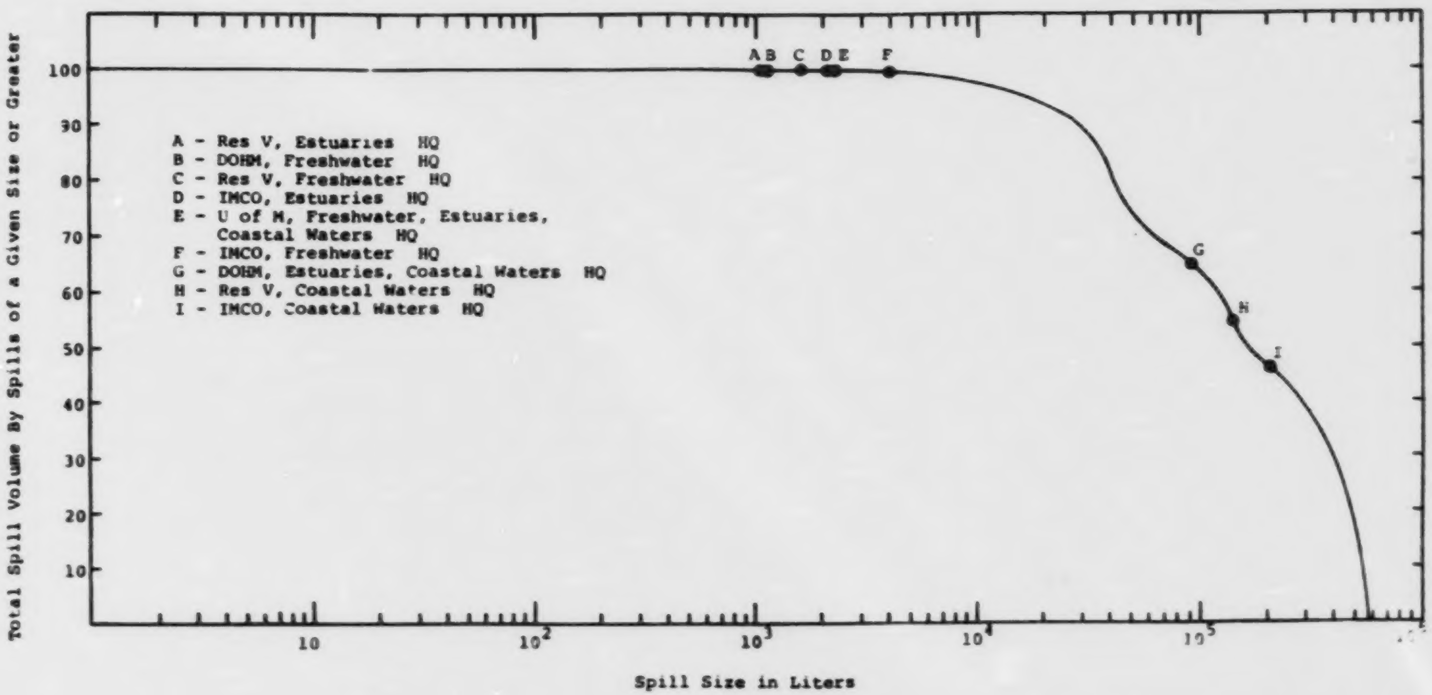

FIGURE V-7. VOLUME PROFILE FOR BENZENE - TOLUENE - XYLENE (BTX) SPILLS

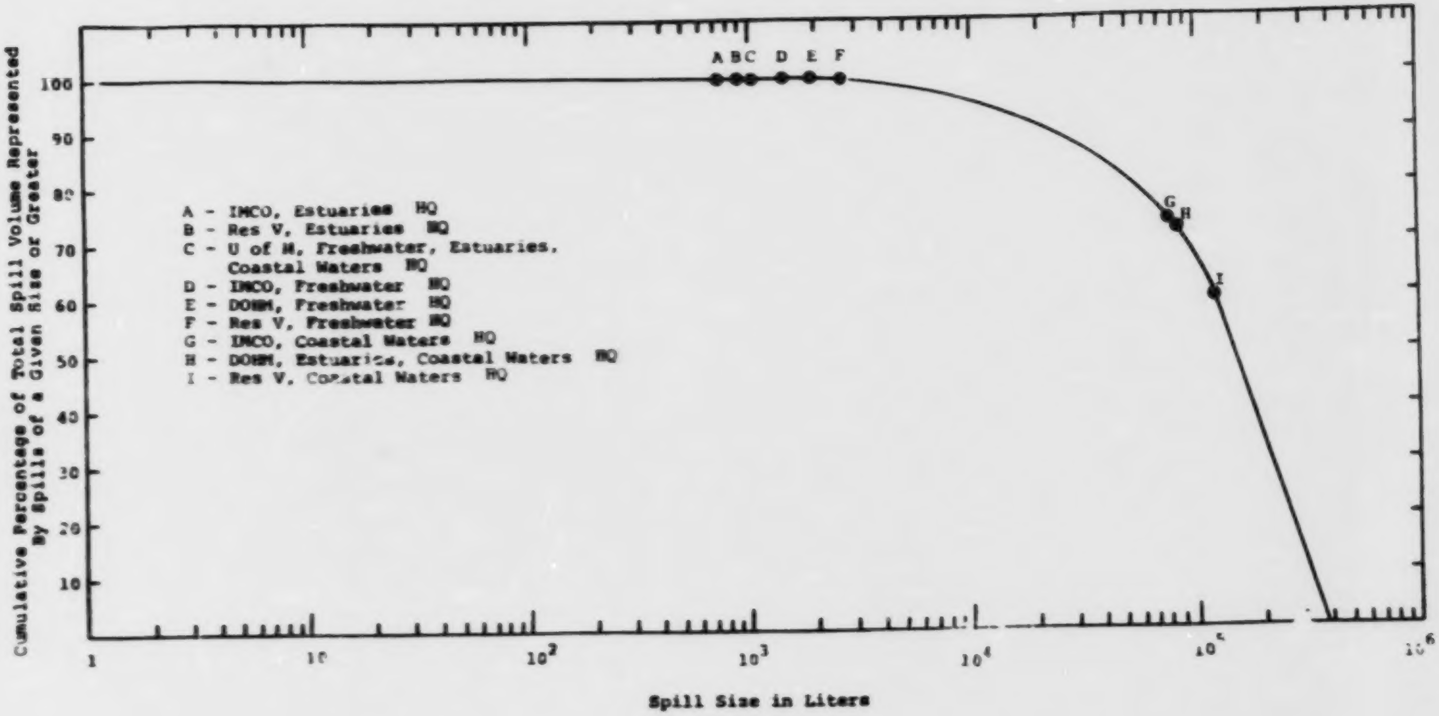

FIGURE V-8. VOLUME PROFILE FOR CAUSTIC SODA SPILLS

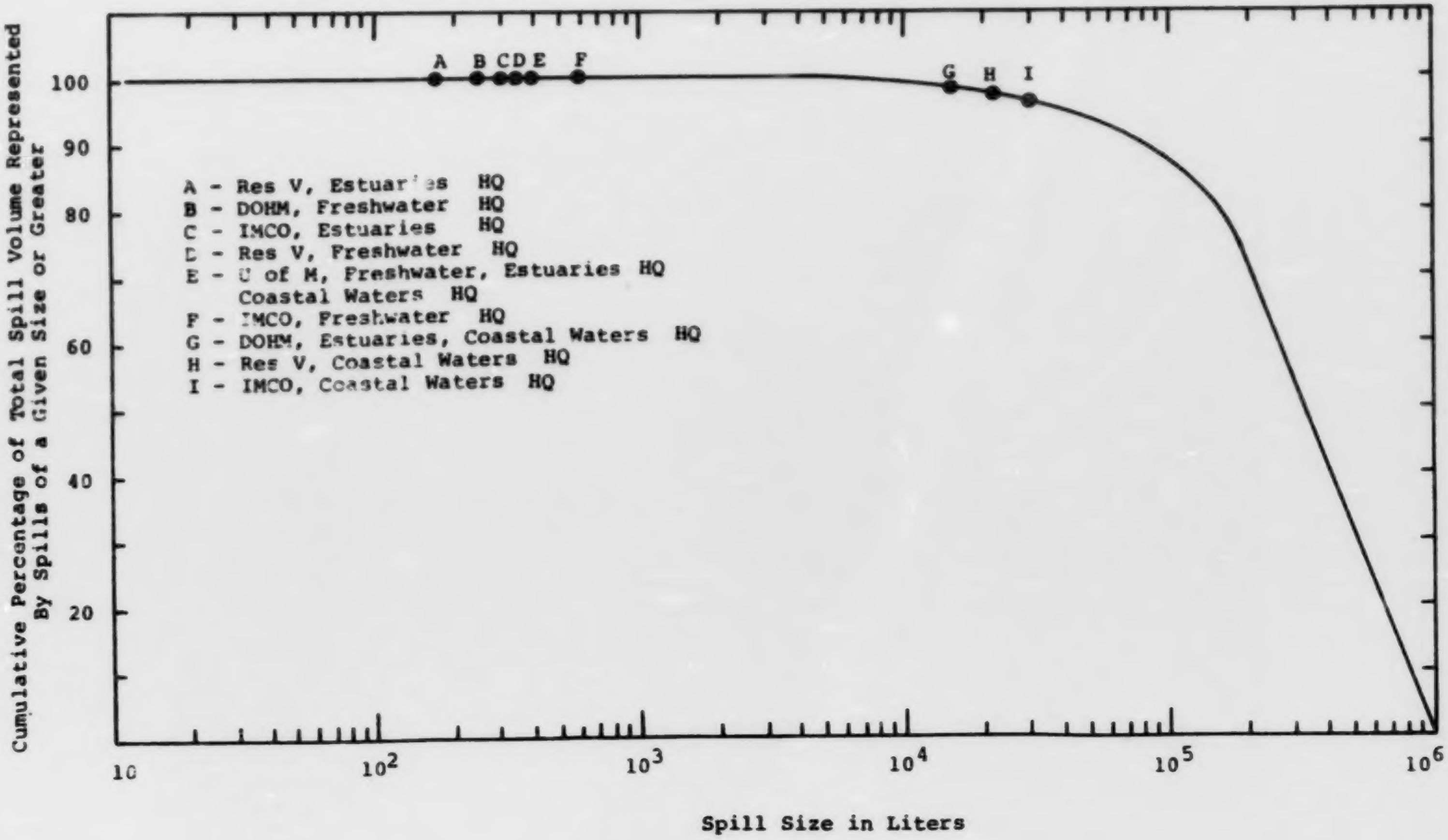

FIGURE V-9. VOLUME PROFILE FOR AMMONIA SPILLS

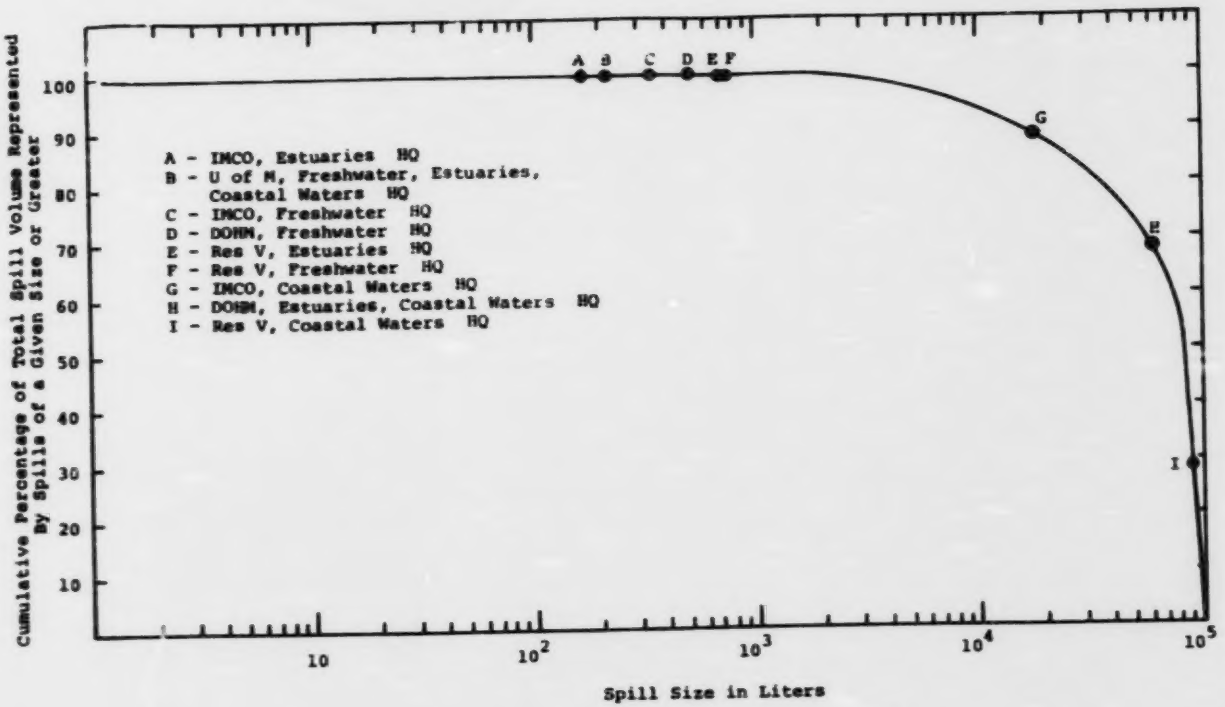

FIGURE V-10. VOLUME PROFILE FOR PHENOL SPILLS

than 99 percent of the volume of material spilled each year, but do not tax limited response resources for the many small spills that also occur. In this respect, the size of the harmful quantities offers balance between administrative costs and environmental benefits. Only for ammonia are the harmful quantities much lower, and in no case were they greater than that point. Significant data with respect to the relative environmental impact of harmful quantities is summarized in Table V-3. The preferred approaches are Unit of Measurement, Resource Value, and IMCO for all but coastal waters. For coastal waters, the Unit of Measurement approach has the least environmental impact. The assumed annual spillage reported is based on average annual losses of 0.0025 percent of production.

Rates of Penalty

Environmental impacts associated with rates of penalty are directly a function of the degree of spill prevention induced through promulgation of an individual approach. Unfortunately, it is next to impossible to predict industry's actual response to individual rates of penalty. To date, industry has claimed that the additional incentive will not alter their present course of action, although it may terminate the marketing of some products.[19] If, however, one assumes that higher rates of penalty will provide incentive for proportionately greater expenditures on spill prevention, then the environmental impact related to rates of penalty will be most favorable for methodologies with the highest rates of penalty. Therefore, methodologies can be ranked in order of preferrence once they are characterized by an average rate of penalty.

To provide for such a comparison, rates of penalty defined by a methodology for all designated hazardous substances were summed and averaged. Rates for the DOHM Methodology were calculated using a weighted average for the various sources based on the percent of total spillage originating from that source category:

Rate of Penalty (R of P) = 0.26 (R of P) rail + 0.62 (R of P) stationary source and motor carrier

Results of the averaging process are presented in Table V-4.

From the relative averages, the Resource Value Methodology would appear to offer the most protection to the environment, followed by the IMCO Methodology, and then the Unit of Measurement and DOHM approaches. This analysis may be somewhat skewed, however.

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[19] Transcripts of the Conference on Hazardous Materials Regulations held in Washington, DC, October 21-23, 1974. Sponsored by Battelle-Northwest and the Environmental Protection Agency.

TABLE V-4

AVERAGE RATES OF PENALTY FOR ALL HAZARDOUS SUBSTANCES ($/lb)

Methodology	Lake	River	Estuary	Coastal Waters
DOHM	4.71	4.71	4.53	4.53
IMCO	36.56	34.32	90.66	0.65
Res V.	603.70	107.39	1349.85	0.69
U of M	4.63	4.35	5.92	4.48

Implicit in the straight averaging of all designated hazardous substances is the assumption 1) that all materials have an equal spill probability and 2) that a given penalty level has an equal impact on all hazardous substances. Clearly, these generalizations are dangerous. Many materials such as pesticides, chlorine, and heavy metals are not spilled often or in large quantities. These same materials are very toxic and therefore have a very high rates of penalty before levels of incentive equivalent to those of lower cost chemicals are approached. From these considerations, it would appear that the optimal measure of penalty rate severity would be the ratio of rates of penalty to chemical price weighted for all hazardous substances by spill probability.

Lacking spill probability statistics on a per substance or even a per generic group basis, grosser levels of differentiation are required. The most easily applied approach is the consideration on those hazardous substances shipped in bulk by barge. These are selected on the premise that spill probability increases with the level of production and size of shipments, and that bulk barge commodities include the majority of all hazardous materials shipped in bulk. Utilizing December 1974 prices as reported in the Chemical Marketing Reporter and the hazardous substance enumerated in Figure V-11, the penalty to price ratios are those presented in Table V-5.

TABLE V-5

RELATIVE SEVERITY OF RATES OF PENALTY USING PENALTY/PRICE RATIOS FOR BULK COMMODITIES

Methodology	Lake	River	Estuary	Coastal Waters
DOHM	37.0	36.0	35.0	41.0
IMCO	52.0	56.0	35.0	6.4
Res V.	35.0	19.0	470.0	1.5
U of M	6.4	7.0	8.4	6.3

Acetaldehyde
Acetic Acid
Acetic Anhydride
Acetone Cyanohydrin
Acrylonitrile
Adiponitrile
Allyl Alcohol
Allyl Chloride
Ammonia
Amyl Acetate
Aniline
Benzene
Butyl Acetate
Carbon Disulfide
Caustic Soda
Caustic Potash
Chlorine
Chlorobenzene
Chloroform
Cresol
Cyclohexane
Dimethylamine
Ethylbenzene
Ethylenediamine
Formaldehyde
Formic Acid
Furfural
Hydrochloric Acid
Hydrofluoric Acid
Napthalene
Phenol
Phosphorus
Phosphoric Acid
Propyl Alcohol
Styrene
Sulfuric Acid
Toluene
Vinyl Acetate
Xylene

FIGURE V-11. DESIGNATED HAZARDOUS SUBSTANCES SHIPPED IN BULK BY BARGE

From this index, the IMCO and DOHM Methodologies provide the most incentive for spill prevention followed by the Resource Value and Unit of Measurement Methodologies. Once again, it is important to emphasize that this implies lower environmental impact only if one accepts the premise that industry will respond directly to the severity of penalties proposed by investing in accordingly more or less spill prevention equipment. Industrial representatives claim that this is not the case. The authors believe, however, that it may well be the case for many smaller operators who are not as publicity conscious as the major firms and who have not led the industry in terms of investment in prevention equipment

SUMMARY

It is postulated that each of the four methodologies developed in the technical portion of this report may have a characteristic effect on the environmental impact of hazardous substance spills. This effect is likely to be a reduction in total spills and total spillage resulting from increased incentive to prevent spills and the rapid reporting of spills in excess of the designated harmful quantity. If this assumption is accepted, it would appear that the IMCO Methodology is optimal with respect to environmental effects because of relatively low harmful quantities and high penalty to price ratios. The remaining three approaches have strong incentives in one area, the harmful quantity designation or rate of penalty determination, and offsetting weak incentives in the remaining areas.

This analysis, notwithstanding, it is generally believed that the differential environmental impacts from any of the approaches offered here is likely to be small compared to the effects of having a law in force which focuses attention on spills and provides for systematic response to spills. Industry presently feels that incentive over and above those presently perceived will not increase their efforts to prevent spills. If this is in fact the case, then a comparative analysis such as that offered here is rendered a moot point.

Aside from the latter points, it is also important to emphasize that there are no data available today to provide estimates of what the present level of environmental effects from hazardous substance spills really is. While estimates can be made as to the volume and number of spills occurring, translation of that into environmental impact is a very problematic exercise. At the same time, however, the promulgation of these regulations will provide the data base necessary to make such a translation. The analysis provided here offers an indication of potential differential effects that would result from implementation of the various methodologies, and in so doing gives a sense of benefits to be derived as a result of the costs indicated in the chapter on Economic Impact.

REFERENCES

1. "Pollution-Caused Fish Kills in 1960," U. S. Department of Health, Education, and Welfare; Public Health Service, 1960.

2. "Pollution-Caused Fish Kills January-September 1961," U. S. Department of Health, Education, and Welfare; Public Health Service, Washington, DC, November 1961.

3. "Report of Pollution -- Caused Fish Kills January-June 1962," U. S. Department of Health, Education, and Welfare; Public Health Service, Washington, DC, September 1962.

4. "Pollution-Caused Fish Kills in 1963," U. S. Department of Health, Education, and Welfare; Public Health Service, Washington, DC, 1963.

5. "Pollution-Caused Fish Kills in 1964," U. S. Department of Health, Education, and Welfare; Public Health Service, Washington, DC, 1964.

6. "Pollution-Caused Fish Kills in 1965," U. S. Department of the Interior, Federal Water Pollution Control Administration, Washington, DC, 1965.

7. "Fish Kills by Pollution in 1966," U. S. Department of the Interior, Federal Water Pollution Control Administration, Washington, DC, 1966.

8. "Pollution-Caused Fish Kills in 1968," U. S. Department of the Interior, Federal Water Pollution Control Administration, Washington, DC, 1967.

9. "Pollution-Caused Fish Kills in 1968," U. S. Department of the Interior, Federal Water Pollution Control Administration, Washington, DC, 1968.

10. "1969 Fish Kills Caused by Pollution," Federal Water Quality Administration, USGPO, Washington, DC, 1970.

11. "Fish Kills Caused by Pollution in 1970," U. S. Environmental Protection Agency, USGPO, Washington, DC, 1972.

12. Field Detection and Damage Assessment Manual for Oil and Hazardous Material Spills, Environmental Protection Agency, Washington, DC, June 1972.

13. Cairns, J. Jr., K. L. Dickson, and J. S. Crassman. "The Response of Aquatic Communities to Spills of Hazardous Materials," Proceedings of the 1972 National Conference on Control of Hazardous Material Spills, Houston, TX, March 21-23, 1972.

14. Minutes of Pennsylvania Sanitary Water Board, Vol. 46-10, p. 01.3, October 16, 1968.

15. Moore, S. L. and S. R. Kin. "Cyanide Pollution and Emergency Duty Train Wreck, Dunreith, Indiana, January 1961," Division of Sanitary Engineering, Indiana State Board of Health, January 1965.

16. OHM-SIRS File, Environmental Protection Agency, Washington, DC.

17. Buckley, J. L. and S. A. Weinen -- data collected during conduct of Contract No. 68-03-0317 -- "Historical Documentation of Hazardous Material Spills," Transmitted November 1974.

18. Personal Communication, Dr. A. L. Jennings, Hazardous and Toxic Substance Branch, U. S. EPA, data developed from OHM/SIRS files 1973, transmitted October 21, 1974.

19. Transcripts of the Conference on Hazardous Materials Regulations held in Washington, DC, October 21-23, 1974. Sponsored by Battelle-Northwest and the Environemtnal Protection Agency.

VI. GENERAL COMPARATIVE EVALUATION

This chapter presents a general comparison of the four technical approaches developed for setting harmful quantities and rates of penalty under Section 311 of PL 92-500. Comparisons made in this section are for the most part direct, attempting to evaluate the four methodologies at face value. These comparisons, when coupled with the Executive Summary (Volume I), will provide the reader with a working knowledge of the technical aspects of the four methodologies. Specific aspects of the methodologies addressed in the following direct comparison include:

- Specificity to water body type
- Specificity to water body size
- Specificity to chemical groups
- Ability to deal with mixtures containing more than one designated hazardous material
- Assumptions and technical rationale
- Severity of penalty schedule and size of harmful quantity.

The comparisons are developed from each perspective in turn, then summarized for convenient reference.

SPECIFICITY TO WATER BODY TYPE

Initially, all approaches except the Unit of Measurement Methodology are keyed to four basic water body types -- lakes rivers, estuaries, and coastal zones. However, in the final analysis none of the methodologies maintain this distinction between four water bodies in computing harmful quantities and rates of penalty as can be seen from inspection of Volume III, Appendix N.

The DOHM Methodology distinguishes only between fresh water and salt water bodies. Harmful quantities are calculated for rivers and estuaries using simplified plug flow models. Since lakes and coastal zones are not amenable to description by plug models, harmful quantites for these two water body types are equated to those derived for rivers and estuaries respectively. Base rates of penalty derived from various costs of prevention can be adjusted by as much as a factor of two. Of the three multiplicative factors used to adjust penalty rates, only two, the toxicity and dispersibility factors, are affected by the water body type. The differences occurring here result from variations in toxicity between fresh and salt waters. The third factor, that is based on the material's ability to persist in the enivronment is constant between water types. Finally, a "locational factor" is suggested as a means of adjusting harmful quantities to the actual flow conditions reported for specific rivers and estuaries. This site-specific adjustment has not been fully developed, and would not be applicable to spills in lakes or coastal zones.

Harmful quantities and base rates of penalty as derived by the Resource Value Methodology are calculated from representative values for water bodies on a per unit volume basis. Separate values are derived for lakes, estuaries, and coastal zones. Values for rivers are equated to those for lakes. Hence, only three distinct water body types -- freshwater (lakes and rivers), estuaries, and coastal zones -- are defined for the purpose of calculating harmful quantities and base rates of penalty. In the determination of the final rate of penalty, intrinsic adjustment factors for persistence (ANF) and dispersion (DISP) are applied to the base rate of penalty. Since both of these adjustment factors distinguish between the four water body types, the Resource Value Methodology final rates of penalty distinguish between all four water body types. This approach also offers optional site-specific adjustment factors which account for actual resource use (ResU) and site specific dispersion (Loc) characteristics. Only the latter of the two extrinsic factors adds any further degree of differentiation with respect to water body types.

The IMCO Methodology calculates harmful quantities and rates of penalty on the basis of the water body values derived in the Resource Value Methodology. This results in the same three distinctions in terms of harmful quantity and base rate of penalty. Despite this similarity, harmful quantities and base rates of penalty derived from these two methodologies generally differ by substantial amounts because of the different approaches to determining critical concentration for individual substances. Adjustment factors to compensate for dispersion and degradability under the IMCO Methodology clearly distinguish between the four water body types. Indeed, the water body into which a hazardous material is spilled determines which adjustment factor is employed. Hence, final rates of penalty under the IMCO Methodology distinguish between the four water body types.

The Unit of Measurement Methodology makes no distinction between water body types in deriving the harmful quantity.

That is, a single harmful quantity is applied across the board for all water bodies. It should be noted, however, that in some cases substantial differences between fresh and salt water aquatic toxicity levels can lead to different harmful quantities for the two types of water. Similarly, base rates of penalty exhibit a distinction between water types only when fresh and salt water toxicities differ greatly since

Base Rate of Penalty = \$1000/HQ.

However, since the IMCO adjustment factors are used to determine final rates of penalty, ultimate consideration of all four water body types is afforded in the final determination of the penalty rate.

In summary, the methodologies might be ranked with respect to water body type specificity as indicated in Table VI-1.

TABLE VI-1

RANKING OF METHODOLOGIES WITH RESPECT TO SPECIFICITY TO WATER BODY TYPES

	Number of Categories Distinguished		Rank
Methodology	Harmful Quantity	Rate of Penalty	(1 = most specific)
DOHM	2	2	4
IMCO	3	4	2
UM	1-2	4	3
RV	3	4+	1

SPECIFICITY TO WATER BODY SIZE

For the most part, the methodologies do not give extensive consideration to the size of the water body as a factor in determining the harmful quantity or the rate of penalty. This is predictable since, except for the stationary source and perhaps barge spills, it is impossible to pre-determine the size of the water body which will receive a spill. Nevertheless, the approaches do, in a number of instances, recognize that the assimilative capacities of water bodies vary directly with their size as does the impact of a given size spill.

In the development of the DOHM model, for example, there is provision made for a "locational factor" which, when incorporated, would adjust harmful quantities for specific stationary sources on the basis of actual flow rates. Similarly, the approach would designate harmful quantities fo barge spills using a much larger flow rate representative of the routes typically plied by barge operations. No modification of the penalty rate for water body size is suggested in the DOHM Methodology although the larger harmful quantities which in most instances would result from the site specific determinations outlined above would reduce the total fines payed by stationary sources and barge operators.

The Resource Value Methodology, through the use of the optional extrinsic factor (Loc), attempts to give recognition to some of the unique dispersive characteristics of various water bodies. Independent variables utilized in the four water body models include:

- Average depth and angle of descent for lakes
- Flow rate and velocity for rivers
- Current velocity and depth for coastal zones
- Estuaries are treated as rivers or coastal water depending upon the locations of the spill.

It should be noted that, with the exception of the river, these variables are not directly proportional to the size of the water body. Further, these factors were designed such that they can be applied to the penalty rate of any one of the four methodologies and, therefore, are not specific to the Resource Value approach.

Under the IMCO and Unit of Measurement Methodologies, there is no recognition of water body size in determining harmful quantity or rate of penalty.

Table VI-2 summarizes the comparison of the methodologies with respect to specificity to water body size.

SPECIFICITY TO PHYSICAL/CHEMICAL CHARACTERISTICS

The law requires that consideration of the toxicity, degradability, and dispersibility be given in determining the rate of penalty for each substance. Specificity to chemical characteristics then refers to the level of resolution afforded by each methodology to these three characteristics.

Both the IMCO and Unit of Measurement Methodologies can be classified as low level of resolution systems at least with respect to their consideration of these characteristics. The toxicity of a material under these four systems is used

TABLE VI-2

RANKING OF METHODOLOGIES WITH RESPECT TO SPECIFICITY TO WATER BODY SIZE

Methodology	Distinction With Water Body Type	Rank (1 = most Specific)
DOHM	Harmful Quantity for Stationary Sources and Barges	2
IMCO	NONE	3-4
UM	NONE	3-4
RV	Extrinsic Adjustment Factor (Loc) for Penalty Rates	1

to assign materials to one of four hazard categories -- harmful quantities and base rates of penalty are then determined for the group rather than the individual material through use of a single critical concentration to represent all material in the group. Thus, loss of resolution is especially noticeable for extremely toxic materials (those with LC_{50}'s <1 ppm) in hazard category A. However, it should be noted that these two methodologies do recognize hazard potentials other than aquatic toxicity including bioaccumulation, human health aspects, and reduction of amenities, whereas for the other two methodologies, aquatic toxicity (LC_{50}) is the only determinant of hazard potential.

With both the IMCO and Unit of Measurement Methodologies, degradability and dispersibility are considered through use of a physical/chemical characteristics grouping scheme. Fourteen physical/chemical groups are created which describe general behavior patterns of materials when spilled into water. Each designated material is assigned to one of these fourteen groups based on its persistence (resistance to natural degradation), volatility, solubility, and specific gravity. Each group is then assigned an adjustment factor between 0 and 1 based on a "subjective determination" of the effects a group's physical/chemical properties will have on the ability of its materials to exert various hazard potentials in given water body types. These adjustment factors are ultimately used to convert base rates of penalty to final rates of penalty. These approaches are also capable of accounting for multiple hazards.

Under the DOHM Methodology, harmful quantities are selected on the basis of a material's aquatic toxicity as represented by 96 hr LC_{50} data. Base rates of penalty derived from the cost of prevention also reflect the specific properties of individual materials through use of three multiplicative adjustment factors:

- A Dispersion-Solubility Factor - function of material's critical concentration and solubility
- A Toxicity Factor - function of material's critical concentration
- A Degradability Factor - function of environmental half-life of the material.

Computation of harmful quantities by the Resource Value Methodology is similar to that employed in the DOHM Methodology. That is, the critical concentration employed are specific to individual materials. Since the base rate of penalty, under the Resource Value Methodology, equals $10,000/HQ, each material is assigned an individual base rate of penalty. Although not specifically stated, the Resource Value Methodology procedures for factoring in dispersibility and degradability are actually grouping procedures similar to those used in the IMCO Methodology. Degradability is accounted for in the intrinsic annuity factor which is assigned on the basis of material classifications (e.g., organic-degradable, inorganic-bioaccumulative). Hence, all materials with similar properties of persistence receive the same annuity adjustment factor. Procedures for assigning the dispersion factor are roughly the same. General material classifications such as "miscible" or "insoluble sinks" are used to describe the general dispersive characteristics of various groups of materials. All materials classified under a given heading are assigned the same dispersion adjustment factor for a given water body type.

The ranking of methodologies with respect to physical/chemical characteristics specificity is shown in Table VI-3.

ABILITY TO DEAL WITH MIXTURES

Hazardous substances will not always be spilled in pure form or in the absence of other chemicals which might react with them. In these cases, the net effect of the combination of chemicals may be additive, antagonistic, or synergistic. In addition, spills might occur in which two or more hazardous substances are released, each in quantities less than those disignated as harmful, but jointly creating a harmful effect. For all of these circumstances, a methodology is needed which will accommodate mixtures in the calculation of harmful quantities and rates of penalty.

TABLE VI-3

RANKING OF METHODOLOGIES WITH RESPECT TO PHYSICAL CHEMICAL CHARACTERISTICS SPECIFICITY

Methodology	Level of Distinction	Rank (1 = most specific)
DOHM	Harmful Quantity and Rate of Penalty assigned to materials individually.	1
IMCO and UM	Four hazardous categories and four water body types; 16 possible harmful quantities and base rates of penalty; 14 physical/chemical groups to adjust for degradability and dispersability.	3-4
RV	Harmful quantity and base rate of penalty assigned to materials individually. Dispersion and degradability adjustment factors assigned based on general material classification.	2

None of the methodologies developed in this study are capable of considering antagonistic or synergistic effects, a direct consequence of the pure compound approach adopted at the onset of the program. Two of the methodologies, the IMCO and the Unit of Measurement, have a limited capability to handle situations in which mixtures or multiple substances are spilled. Since both of these methodologies use a grouping approach, situations involving the spillage of materials in the same hazard categories can be handled on a strictly additive basis. For example, if the harmful quantity for category X material was 1,000 pounds and a mixture containing 600 pounds of material A and 500 pounds of material B, both members of category X, were spilled, then the harmful quantity would have been exceeded. However, the penalty for this spill will still have to be computed as the sum of the fines for the individual materials.

If one were willing to accept the assumption that hazards associated with individual materials were strictly additive, then a concept of "partial harmful quantities" could be used with all four methodologies to deal with spills of mixtures. Such an approach, although not developed in the technical document section of this report, would be relatively easy to administer provided that the constituents and quantities comprising given mixtures were known. Fractions of the harmful quantity for each substance would be summed and if the sum exceeded a value of 1.0, a harmful quantity would be said to have been spilled. The major drawback with such an approach is, of course, the need to calculate harmful quantities after spills have occurred, and failure of this approach to recognize antagonisms or synergisms resulting when individual hazardous materials are mixed together. The alternative to this is the determination of separate harmful quantities and rates of penalties for specific mixtures. Such a determination for the more common industrial mixtures (e.q., untreated pulp mill effluents, pickling liquors, etc.) would afford more equitable treatment of materials relative to a strictly additive approach, but would not comply directly with the mandate in Section 311 to address "compounds and elements." As noted in the administrative evaluation section of this volume, the limited ability of the present methodologies to deal with mixtures may be an indication of future regulatory problems.

Table VI-4 summarizes the raning of the various methodologies with respect to capability to deal with mixtures.

TABLE VI-4

RANKING OF METHODOLOGIES WITH RESPECT TO ABILITY TO DEAL WITH MIXTURES

Methodology	Ability to Deal with Mixtures	Rank (1 = greatest ability)
DOHM	NONE	3-4
IMCO	Within each of 4 categories	1-2
UM	Within each of 4 categories	1-2
RV	NONE	3-4

ASSUMPTIONS AND RATIONALE

Each of the methodologies for determining harmful quantities and rates of penalty is constructed within an avowed technical rationale which in turn relies on supporting data and simplifying assumptions. Some commonality exists between all of the methodologies but each one also offers a unique approach or orientation to the problem of finding a rational basis for the forthcoming spill regulations under Section 311. Discussion in this section will analyze the rationale for each methodology including the underlying assumptions and data. Following the discussion of elements common to all methodologies, each methodology is analyzed in the following categories:

1) Basic orientation and rationale

2) Technical basis for calculation of harmful quantity

3) Technical basis for calculation of rate of penalty

4) Technical basis for adjustment factors.

Assumptions and Rationale Common to all Methodologies

A basic underlying concept common to all methodologies is that the penalty assessed for a spill of hazardous material be of a civil as opposed to a criminal or punitive nature. Such a philosophy is in accord with Congressional intent -- namely that of encouraging spill prevention by providing financial sanctions designed to deprive offenders of any economic advantage from non-compliance with the "no discharge" objective stated in the preamble to Section 311. As noted in the following sections, some methodologies are more successful than others in meeting the spirit and/or intent of the law.

All methodologies use a pure compound approach, and in so doing appear to be consistent with congressional intent, specifically Section 311(b)(2)(A) of the law which instructs that elements and compounds be designated as hazardous substances. From a technical perspective a pure compound approach is by far the most practical due to the general lack of specific data on mixtures of hazardous substances and the transient nature of mixture compositions. For all practical purposes the number of mixtures of hazardous substances or mixtures of non-hazardous substances that are hazardous is infinite. Nevertheless, as noted in the previous section, the use of a pure compound approach to develop spill regulations may lead to future administrative and regulatory difficulties as hazardous wastes and other non-standard materials grow in number and volume.

A third concept common to all four methodologies is that of "critical concentration". Closely related to this concept is the problem of determining what constitutes substantial harm. The convention adopted by all methodologies is that when a significant volume of water is exposed to the critical concentration, substantial harm to the environment has occurred. Therefore, definition of substantial harm (in the absence of specific Congressional guidance) involves two distinct issues:

1) how much material is required to damage water; and

2) how much water, when damaged, represents substantial harm to society.

The first issue is addressed through the use of a critical concentration defined, where possible as the 96 hr LC_{50} for a median receptor. Implicit herein is the notion that 50 percent mortality to an aquatic community constitutes substantial harm. This is, of course, debatable as it entails value judgments on the part of the authors. The second issue is addressed through the concept of critical volume, except in the case of the Unit of Measurement Methodology. This concept is used in each methodology by employing means to derive and designate significant volumes of water. Once again value judgments are a necessity and each is evaluated with respect to the methodology in which it is used.

Finally, it should be noted that the toxicological data for the various materials considered in this study are not complete. In many instances where data were unavailable, assumed values were used. The assumptions are well documented in Appendix A of Volume III.

While the preceding considerations bear heavily on the ultimate nature of derived harmful quantities and rates of penalty, they are common to all four methodologies and, therefore, do not affect the relative merits of the individual approaches taken.

DOHM Methodology

Orientation and Rationale - The orientation and rationale for determining harmful quantity and for deriving rates of penalty are completely separable in the DOHM Methodology. The harmful quantity determination is based on simplified plug flow models and statistical analysis of U. S. water bodies. The former operation (plug flow model) is used to determine how much of a given material it takes to contaminate a unit volume of water to the critical concentration. The latter operation (statistical analysis) is used to select a significant volume of water which, when contaminated to the critical concentration, constitutes substantial harm to the environment. The derivation of penalty rates under this methodology is based on estimated costs of spill prevention from various spill sources. Conceptually, this approach comes closest to complying with Congressional intent in that the penalty rates are specifically structured to provide incentive for investment in spill prevention.

Technical Basis of Harmful Quantities - The simplified plug flow models used in this methodology to determine harmful quantity are crude approximations of real world water bodies.

In the final analysis they constitute a model of instantaneous, homogeneous mixing to a predetermined concentration level. An obvious alternative to the use of the simplified plug flow models is the use of sophisticated computer models to simulate the movement of spilled hazardous materials in various water bodies. Many of these types of models are available. They have proved to be useful for predictive purposes. However, in almost all cases, they are very site-specific requiring actual physical, chemical and hydrodyanmic data from the appropriate water body. If such a model were to be considered for general regulatory use, "universal parameters" for all water bodies of a given type would have to be assumed. It is doubtful that such an approach would add sufficient resolution to the plug flow model to justify its use. The plug flow models are deemed to be consistent with the level of resolution required in this work. This is especially true when one considers that substantial harm and its determination is a very elusive concept requiring subjective value judgments if quantitative caluclations are to be performed.

The statistical analysis used to derive the critical volumes for rivers and estuaries in the DOHM approach provides a good estimate of the size distribution of these water bodies in the United States. The selection of the 95th percentile as the threshold of substantial harm is somewhat arbitrary. Since the basic data is provided in the text, any alternative percentile can be selected and used as the basis for determining the critical volume.

The assignment of identical harmful quantities for all fresh waters and all saline waters is highly arbitrary with no real technical justification. This stands a major weakness in overall rationale.

Technical Basis for Rate of Penalty - Conceptually, the derivation of penalty rates form spill prevention costs is a well founded approach; however, problems associated with the adequacy of the data base for cost of prevention calculation and additional problems inherent in the calculation procedure detract from the credibility of the final numbers.

Estimates on costs associated with various spill prevention techniques were derived for the most part from data received from representative industries engaged in the manufacture and/or transport of hazardous materials. Response to these requests was somewhat discouraging. Many of the industries contacted stated that they were unable to separate spill prevention costs from other costs associated with their operation. Additionally many industries could not estimate how much of their product was spilled on an annual basis since, with the exception of catastrophic spills, no historical data had been collected.

Two MCA member firms did respond to the request by providing data on 1) the cost of providing containment for a single facility and 2) the average reduction in spillage resulting from those measures taken. Similar data was provided by a member firm of the American Association of Railroads for improving the integrity of tank cars. MCA member firms also provided cost of prevention data on their chemical barge operation. (This information was supported in part by an MCA survey of barge spill probabilities.) No useable data was received from the trucking industry other than an indication that most spills originating from that sector occur at transfer stations. The details of this data are contained in the technical portion of the report. While there is no reason to believe these data are inaccurate, they represent a very small portion of the total industry and may simply not be representative. Furthermore, since the firms which did respond were often exemplary ones in terms of their progressive attitudes towards spill prevention it is likely that the limited data received are biased toward higher penalty rates. Specifically, the cost of prevention, as derived in this approach, is really a ratio of the dollars spent on spill prevention to the realized reduction in spillage. Costs associated with various spill prevention measures are relatively fixed and can be determined in a straight forward manner. For example, costs of diking tank farms are relatively constant with most variations resulting from differences in geographic location. Similarly, the cost differential between double and single hulled barges is well known. However, these costs are only half of the required data base. The other half, spill reduction, is very much a function of the level of spillage is much smaller than it would be for a firm which had a high frequency of spills prior to the installation of special equipment. The net effect, then, of using data from exemplary firms is that the denominator of the cost of prevention ratio is made smaller thus increasing the apparent cost of prevention.

Finally, it should be noted that costs of prevention derived in this study are average costs for all hazardous substances. In reality some variation exists between costs associated with the prevention of spillage of different generic groups of hazardous materials. These are often a function of such properties as volatility, corrosivity, and flammability.

Technical Basis for Adjustment Factors - The adjustment factor, rk, is essential to the DOHM Methodology since the cost of prevention is determined without any consideration of the toxicity, dispersibility, and degradability of the material. Indeed, without this adjustment factor all designated materials would have identical rates of penalty when spilled from the same source type.

The adjustment factor, rk, is formed as the product of three independent variables which individually account for the three aforementioned considerations required by the law. The relationships used to derive these variables can be described as follows:

- Toxicity Factor (T) - Increases with decreasing 96 hr LC_{50}
- Dispersion-Solubility Factor - Increases with increasing solubility to 96 hr LC_{50} ratio
- Degradability Factor - Increases for more persistent non-degradable materials.

The exact relationships for these factors are contained in the technical report. Largely, these relationships reflect the general trends in hazard potential that the authors felt to be appropriate functions of toxicity, dispersibility, and degradability of a given material. The three are treated as multiplicative and no weighting factors are included. There is no technical basis either for the relations themselves, or for their combination in a multiplicative manner. However, the impact of these factors on final rates of penalty is relatively insignificant since the final rate of penalty can only vary from the derived cost of prevention by a factor of two.

Resource Value Methodology

Orientation and Rationale - The Resource Value Methodology takes its name from the underlying rationale that fines assessed for hazardous materials spills should be proportional to damages to aquatic resources resulting from the spill. The philosophy then is one of requiring the spiller to remit to society an amount equal to the damages caused by his action. Such an approach is similar to what one would encounter in a civil liability suit.

The method for defining substantial harm under this methodology is couched in an attempt to set the harmful quantity at a level where the probability of significant spills being reported is optimized. The decision analysis leading to the selection of $5,000 worth of damages to the environment as the threshold of harm has little to do with the actual level of harm although arguments are made in the technical documentation as to the significance of the $5,000 level in the eyes of Congress. This subject is discussed more fully in the next section.

Technical Basis for Harmful Quantity - The procedure for the determination of the harmful quantity as the product of critical concentration and critical volume is the same as in the DOHM Methodology. Indeed, the same critical concentrations are used in both methodologies; however, the determination of critical volume between the two is quite different. In the Resource Value Methodology the threshold of harm is an ecomomic one derived from assumptions concerning legislative intent and from a desire to set harmful quantities at a level that would encourage reporting of major spills. The assumption that Congress, in setting the criminal fine for non-reporting of harmful quantity size spills at maximum of $5,000, felt that damage on the order of $5,000 represents substantial harm, is questionable. However, from other sections of the law,* it would apperar that $5,000 is high if anything.

The second basis for the selection of $5,000 in damages as substantial harm, although probably desirable from a practical point of view, does not bear on the issue of significance. It serves more as a convenience taken for pragmatic reasons unrelated to defining substantial harm.

Technical Basis for Rate of Penalty - The calculation of base penalty rates in this methodology is simple and direct. Fines for spills of individual materials are based on the toxicity of the material which is viewed as a measure of how much water a unit mass of the material is capable of damaging. The penalty rates are computed by simply dividing the value of the water body types (given on a per unit volume basis) by the critical concentration (96 hr LC50) of the material. Such a procedure assumes instantaneous and complete mixing of the spilled material -- a worst case assumption.

Much of the effort in this methodology was devoted to determining how and at what levels aquatic resources are valued. Results reported in the technical portion of the study indicate that there is a wide variation in the values placed on various water bodies throughout the United States. Much of the spread in the data resulted from the fact that the values were based on different end uses. A key simplifying assumption made in the Resource Value approach was that only values based on recreation use for freshwater bodies be used. The authors contend that this is the only use most consistently affected by hazardous materials spills. Furthermore, they imply that damages to other uses of the water (e.g., municipal water supply) are more easily recovered through civil court actions since the damaged parties are more easily identified and the actual amount of damages more easily ascertained. Both of these assumptions are a bit naive.

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*For example, $5,000 under Section 311(b)(6) - the Coast Guard maximum fine for the discharge of a harmful quantity. Also $500 - $5,000 under Section 311(b)(2)(B)(iii)(aaa).

It should also be pointed out that the unit value of the "water" is not constant at least for lakes. Figure IV-4, Volume II, for example, shows a decreasing marginal unit value as lake size increases. Thus for larger size lakes it is quite possible that the estimate of $200/AF (based on a 50 acre-foot lake) is too high.

Finally, it is believed that the assumption equating river water to lake water values is not particularly strong from a technical standpoint. The valuation procedure for estuaries and coastal waters employs a much stronger rationale.

Technical Basis for Adjustment Factors - The Resource Value Methodology includes two intrinsic adjustment factors to account for degradability and dispersibility, and two optional extrinsic adjustment factors which can be applied on a site-specific basis.

The first intrinsic factor, Anf, accounts for the persistence of various general classes of materials in each of the four body types. Since the base rate of penalty is derived from the present worth of the water bodies it is quite logical to adjust this value downward for those materials which, due to their non-persistent characteristics, are not capable of permanently damaging the water body. Additionally, the factors recognize the ability of water bodies such as rivers with high dispersive capacities to remove ecologically and chemically persistent materials. Actual values assigned to each of the material classifications and water body types (see Table IV-2, Volume II) were derived by estimating the number of years the adverse effects of a spill of a given class of material would persist. Since this is an estimate of "effect persistence" as opposed to the actual presence of the material, a minimum duration of one year is used for the least persistent materials.

The second intrinsic factor (Disp) is quite similar to the IMCO adjustment factor except that persistence is not included as part of the material classification. Eight general material classifications are used to describe the dispersive characteristics of various materials in the four water body types, a factor of 1.0 for "miscible" substances was used as a datum in all four water body types. Adjustment factors for other classes of materials were assigned based on a subjective estimation of the extent to which they were capable of being dispersed relative to the "miscible" substances. Values for these dispersion factors ranged between 0.27 and 1.35 (see Table IV-4, Volume II).

The product of these two adjustment factors was then applied to the base rate of penalty ($5,000/HQ) to arrive at a final rate of penalty. Since no weighting factor was used, there is an implicit assumption that degradability and dispersibility are of equal importance.

Both extrinsic factors are optional and are intended for use as after the fact adjustments to account for local variances from the average water body values and water body characteristics used to derive the rates of penalty. The first factor, ResU, reflects the extent to which the value of the spill environment deviates from the average value used to derive the base rate of penalty. Application of this factor requires a relatively subjective judgment on the part of the regulatory authority. It is envisioned that in some situations, utilization of this factor may lead to controversy.

The second factor (Loc) is more easily applied. It is intended to consider local dispersive forces and hence offset the simplify assumption of instantaneous uniform mixing to the critical concentration as a function of key physical and hydrodynamic parameters. This volume was then compared to the volume potentially exposed under the instantaneous mixing assumption. The Loc factor is equated to the ratio of these two volumes reflecting the percentage of potentially, critically contaminated volume, actually contaminated (as predicted by the computer model). After the fact application of this factor is relatively easy, provided that the key parameters are known. For example, for spills into a river, flow rate, velocity, and critical concentration must be specified to select the appropriate Loc adjustment factor from the tables provided in the technical report. The adjustment factor from these tables is then applied directly to the rate of penalty. Since determination of the key parameters requires no subjective judgment on the part of the regulatory authority, it is unlikely that utilization of this factor will meet the type of resistence potentially associated with the ResU factor.

IMCO Methodology

Orientation and Rationale - In some respect, the concepts underlying the IMCO Methodology are identical to those of the Resource Value Methodology. Substantial harm is defined as $10,000 worth of damages to the environment and penalty rates are based on the rationale and values formulated in the Resource Value Methodology. A substantial difference occurs between the two methodologies in the determination of critical concentration. In the IMCO Methodology materials are grouped on the basis of five hazard potentials and a critical concentration is assigned to represent each group of materials. The net effect of this grouping procedure is to increase the ease of administration at the price of a lower level of resolution.

It is also of importance that the IMCO Methodology considers hazards other than toxicity to aquatic life in determining the harmful quantity and rate of penalty of a given material. This consideration is extended in two ways:

1) In the determination of which hazard category a material is assigned to, and

2) In the physical/chemical adjustment factor.

Finally, and most noteworthy, is that the IMCO Methodology is compatible with the proposed regulations of the 1973 International Convention on Marine Pollution in that it adopts the hazardous materials profiling and categorization system contained in the proposed convention.

Technical Basis of Harmful Quantity - Under the IMCO system, the level of harm associated with a given material is a function of the category to which it has been assigned. Assignment to a particular category is in turn a function of the relative hazards of the material under the five hazard potentials considered by the IMCO system. Once a material has been assigned to a hazard category, it is treated like all other materials in that category. That is, since all materials in a given hazard category have the same way as in the Resource Value Methodology, the number of possible harmful quantities is reduced to four per water body -- one for each hazard category.

A few comments on the implications of the IMCO grouping system are in order. The profiles used to assign materials to hazard categories are quite simple to apply, each having a well-defined set of guidelines (with the possible exception of amenities) for assigning profile ratings. However, the system used to assign materials to categories on the basis of these profiles is subjective embodying in the final analysis the value judgments of the international body that formulated the original IMCO rating/classification system. Such value judgments are,of course, unavoidable when one chooses to consider multiple hazards since there is no rigorous or quantitative way of comparing such hazards as bioaccumulation potential, damage to living aquatic organisms, and human health. There simply is no common denominator. Hence the acceptability of the IMCO Methodology is, to a large extent, a function of the acceptability of the value judgments inherent in the classification system.

The grouping procedures for the IMCO system also tend to reduce or mitigate the harmful quantities and rates of penalty assigned to extremely toxic materials -- specifically those with 96 hr LC_{50} values below 0.1 ppm. This occurs in hazard Category A where the critical concentration is set at 0.5 ppm but where constituents are all materials with 96 hr LC_{50} values in the parts per billion range, the ratio of their toxicity to the representative critical concentration can span several orders of magnitude whereas in the other three categories, the maximum difference is one order or magnitude. This factor is quite apparent when one compares IMCO and Resource Value penalty rates for some of the more toxic pesticides and heavy metals. This relative insensivity of the IMCO methodology to individual critical concentrations is considered to be a weakness especially for highly toxic materials.

Technical Basis for Rates of Penalty - The technical bases for the IMCO rates of penalty are identical to those of the Resource Value Methodology.

Technical Basis for Adjustment Factors - Adjustment factors for dispersion and degradability are derived subjectively through the use of a DELPHI technique. No adjustment factor for toxicity is defined since toxicity is accounted for in the base rate of penalty. Adjustment factors in the IMCO Methodology are applied to the base rate of penalty as compensating mechanisms. They are intended to reflect the extent to which the dispersion and degradability of a material affect its ability to exert its full hazard potential. Since the base rate of penalty is an expression of full hazard potential (essentially a worst case premise), the net effect of the adjustment factors in most instances is to reduce the base rate of penalty.

The use of a DELPHI procedure to derive the adjustment factors is based on the assumption that there is no rigorous way of determining how a material's physical/chemical properties affect its toxicity in a spill situation. In the general case this is probably a valid assumption.

The format of the adjustment factors is consistent with the multiple hazard approach of the methodologies. Adjustment factors are derived for each hazard potential in each of the four water body types. It is also noteworthy that for materials with multiple hazard potentials of the same order of magnitude the individual adjustment factors related to each hazard are additive. This means that for materials exerting multiple hazards of the same intensity, final rates of penalty can exceed the base rate.

Unit of Measurement Methodology

Orientation and Rationale - The Unit of Measurement represents a strict interpretation of the law. The rate of penalty is the ratio of an independently derived unit of measurement and the fixed monetary amount specified by Congress. Here, an attempt is made to recognize units that are specific to certain trade practices (e.g., tank cars, drums, tons, etc.). This attempt, in the final analysis, is not completely successful. Although harmful quantities are specified in round lot units used in the trade (e.g., 55 gallon drum, 4000 gallon tank car), final rates of penalty are still given in terms of standard units.

The Unit of Measurement Methodology is developed within the context of the IMCO system. That is, the IMCO Methodology is used to differentiate between materials on the basis of toxicity, dispersibility, and degradability. The two systems differ in their determination of substantial harm and the bases for the rate of penalty.

Technical Basis of Harmful Quantity - In the Unit of Measurement Methodology, derivation of the unit of measurement and harmful quantity are closely related. One of the constraints placed on the unit of measurement is that it be large enough so that when spilled it is likely to result in substantial harm. This convention leads to the selection of a 4000 gallon tank truck as the harmful quantity for IMCO Category D materials. Harmful quantities for other IMCO category materials are derived to reflect the ratio of their respective critical concentrations to that for Category D and then are rounded off to more standard quantities.

Unlike the other methodologies, no attempt is made to define substantial harm in the Unit of Measurement Methodology. Rather large harmful quantities were selected under the stated assumption that there would be little disagreement as to the ability of these quantities to cause substantial harm.

Hence, instead of setting a threshold of harm, the Unit of Measurement Methodology proposes harmful quantities that are "no less than and probably greater than" the quantities actually required to cause substantial harm. It is of interest that for some materials the Unit of Measurement harmful quantities are less than the harmful quantities derived by other methodologies. This, of course, raises some doubts as to the validity of the underlying assumption that all harmful quantities in the Unit of Measurement Methodology exceed the amount actually required to cause substantial harm, or conversely, that the other methodologies are operating above the avowed threshold of harm.

Technical Basis for Rates of Penalty - The most compelling aspect of the Unit of Measurement penalty rates is that they were derived in the precise manner prescribed by Congress -- the simple association of a fixed monetary rate to an independently derived unit of measurement. The selection of the units of measurement is arbitrary and difficult to defend. For that matter, any unit of measurement would be difficult to defend since, in the actual trade practice, hazardous materials are dealt with in many different and constantly changing units which, for the most part, have little relation to the materials' hazard potentials. If penalty rates are to be scaled to the level of hazard posed by a given material, such a procedure places a severe constraint on the ability of penalty rates to reflect the order of magnitude differences that exist between the hazards of designated materials.

The Unit of Measurement Methodology does not adhere strictly to its stated objective of deriving uints of measurement common to the usual trade practice. Only the IMCO Category D unit of measurement, the 4000 gallon tank truck, is derived in this way. Units of measurement for the other three categories are derived from this base to reflect, to a limited degree, the higher levels of hazard potential associated with other categories.

While the use of the methodology prescribed by Congress is the major strength of the Unit of Measurement Methodology, it is also its major weakness with respect to underlying rationale and technical basis. There simply is no technical justification for the system beyond as assumed basis for the wording in the law itself. Therefore, in the absence of any evidence to the contrary, one must assume that the entire approach is rather arbitrary.

Technical Basis for Adjustment Factors - Unit of Measurement adjustment factors for dispersibility and degradability are identical to those of the IMCO Methodology.

Relative Assessment of Assumptions and Rationale - Each methodology has been shown to have its own strengths and weaknesses with respect to the underlying rationale and the technical data used to support that rationale. It is difficult, therefore, to make a direct comparison between the four approaches without relying heavily on judgment factors. With that in mind, the methodologies were ranked as summarized in Table VI-5. The Unit of Measurement Methodology was given the lowest rating because of the lack of any strong technical rationale in the construction of its rate of penalty.

TABLE VI-5

RANKING OF METHODOLOGIES WITH RESPECT TO RATIONALE AND TECHNICAL ASSUMPTIONS

Methodology	Strengths	Weaknesses	Rank*
DOHM	Strong in handling of streams. Good data base for selection of critical volume.	Poor data base for setting rates of penalty; inadequate for lakes and coastal waters.	3
IMCO	Good data for rates of penalty base.	Weak rationale for defining threshold of harm; subjective treatment of persistence.	2
UM	Complies with the letter of the law.	Lack of underlying technical rationale and supporting data.	4
RV	Good data for rates of penalty base.	Weak rationale for defining threshold of harm.	1

*1 = strongest rationale.

While the DOHM Methodology is considered to have a very strong base for harmful quantity derivation, it was ranked behind the IMCO and Resource Value Methodologies because the supporting data for the rates of penalty are too limited and rates of penalty are considered by the author to be more impactive part of the regulation than harmful quantities. The IMCO and Resource Value Methodologies differ only in the grouping concept and the adjustment factors. The grouping approach in the former methodology was required to replicate the IMCO/GESAMP rating/classification system. The IMCO adjustment factors are similar to those of the Resource Value Methodology; however, it is relieved that under the IMCO Methodology the importance of persistance is underestimated. For these reasons, the Resource Value Methodology is conceded a slight edge.

SEVERITY OF PENALTY

Many of the impacts associated with an approach, and the ease with which the approach can be implemented and enforced, are direct results of the severity of its rates of penalty. High penalties may motivate greater precautions for spill prevention, but will also have commensurately higher economic impacts on industry when assessed. Furthermore, higher rates of penalty are more likely to be challenged. Since many comparisons between approaches will draw heavily upon the severity of associated rates of penalty, it is important to establish a general measure of overall penalty severity and apply this measure to the four approaches evaluated herein.

The obvious choice in seeking a general measure is the average rate of penalty for all of the designated hazardous substances. Such an average, however, gives equal weight to all substances with no regard for the probability of a spill of that material. A much more desirable measure would be a weighted average with each value adjusted according to the spill potential of the specific material. Unfortunately, information required to calculate a weighted average is not availbale. Historical data and knowledge of industrial operations does, however, suggest trends in spill probability for generic groups of materials. Therefore, if average rates of penalty are derived for generic groups of chemicals, a subjective ranking of approaches based on severity of penalty can be made. The average rates of penalty assocaited with the four methodologies are given in Table VI-6 for each of seven generic groups encompassing all of the designated hazardous substances.

Of the groups listed, only the first three are considered major threats to navigable water. The fourth group, inorganic gases and liquids, does contain ammonia which has been spilled in large quantities, but for the most part this group contains gases or other reactive materials shipped in special containers (e.g., chlorine and phosgene). Group V materials, for which the probability of a major release is considered to be quite low, are inorganic salts which are typically shipped as solids in small lots. While pesticides and metal salts (Groups VI and VII) have recieved a great deal of attention recently, neither are typically shipped or spilled in large amounts. Therefore, only the first three groups were used to determine relative severity. Rating on this basis, the order of ascending severity for the four approaches is Unit of Measurement, Resource Value, IMCO, and DOHM. Therefore, on the average for materials with the greatest spill potential, the Unit of Measurement Methodology assesses the lowest rates of penalty, and the DOHM Methodology the highest.

TABLE VI-6

AVERAGE RATES OF PENALTY AS DERIVED BY EACH METHODOLOGY FOR GENERIC GROUPS ($/lb)*

	Lake				River				Estuary				Coastal Waters			
Group	DOHM	IMCO	ResV	UM	DOHM	IMCO	ResV	UM	DOHM	IMCO	ResV	UM	DOHM	IMCO	ResV	UM
Acids and Bases	(3) 3.71	(2) 5.52	(1) 8.13	(4) 0.70	(3) 3.71	(1) 7.04	(2) 4.55	(4) 0.89	(3) 3.61	(2) 15.30	(1) 430.60	(4) 1.00	(1) 3.61	(4) 0.08	(2) 1.00	(3) 0.56
Organic Materials	(2) 4.25	(1) 8.55	(4) 1.31	(3) 1.88	(2) 4.25	(1) 9.07	(4) 0.62	(3) 1.14	(3) 4.24	(2) 19.90	(1) 65.56	(4) 1.29	(1) 4.24	(4) 0.13	(3) 0.18	(2) 0.88
Detergents	(1) 3.55	(2) 0.53	(3) 0.31	(4) 0.07	(1) 3.55	(2) 0.60	(3) 0.19	(4) 0.07	(2) 3.66	(1) 4.12	(3) 2.45	(4) 0.25	(1) 3.66	(3) 0.03	(4) <0.01	(2) 0.13
Inorganic Gases and Liquids	(4) 4.30	(1) 35.08	(2) 28.33	(3) 4.45	(3) 4.30	(1) 31.55	(2) 15.57	(4) 4.00	(3) 4.19	(2) 63.01	(1) 70.01	(4) 4.12	(1) 4.19	(3) 0.50	(4) 0.16	(2) 3.47
Inorganic Salts (non-metals)	(2) 4.54	(1) 9.63	(3) 4.04	(4) 1.22	(2) 4.54	(1) 10.25	(3) 2.30	(4) 1.29	(3) 4.45	(1) 16.41	(2) 12.68	(4) 1.06	(1) 4.45	(3) 0.11	(4) 0.02	(2) 5.77
Pesticides	(4) 4.93	(2) 84.43	(1) 3,127.54	(3) 10.70	(4) 4.93	(2) 78.56	(1) 553.45	(3) 9.96	(4) 5.02	(2) 220.19	(1) 6,757.62	(3) 14.48	(2) 5.02	(4) 1.45	(3) 3.12	(1) 10.09
Metal Salts	(3) 5.00	(1) 38.99	(2) 12.43	(4) 4.94	(2) 5.00	(1) 36.00	(4) 2.85	(3) 4.56	(4) 4.60	(1) 95.25	(2) 59.15	(3) 6.22	(2) 4.60	(3) 0.74	(4) 0.02	(1) 5.12

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*For rankings in parentheses, 1 = highest rate of penalty

SIZE OF HARMFUL QUANTITY

The size of derived harmful quantities will also affect the impact and ease of administration of any individual approach. The same considerations made for severity of penalty hold for the size of harmful quantities. Therefore, a similar analysis by generic group was performed. The averages obtained are presented in Table VI-7.

As in the case of severity of penalty, only the first three groups are considered of major spill significance. Averaging the ranking from these groups, the four approaches in order of ascending size of harmful quantity are Unit Measurement, DOHM, IMCO, and Resource Value, respectively. Therefore, on the average for materials with the greatest spill potential, the Unit of Measurement Methodology yields the smallest harmful quantities and the Resource Value Methodology, the largest.

SUMMARY OF GENERAL COMPARISONS

For reader convenience, the results of the general comparative evaluation are summarized in tabular form in Table VI-8. These results are used as "direct inputs" to the administrative evaluation which follows.

ADMINSTRATIVE EVALUATION

In comparing the various aspects of the four methodologies developed in the technical portion of this study, it is important to consider (in addition to the economic and environmental implications) those aspects of each methodology relating to the ease of implementation and enforcement. This section attempts such as assessment by presenting an analysis of the alternative methodologies from an adminstrative point of view.

This comparison begins with a review of the basic characteristics of the respective methodologies and proceeds to a discussion of results in terms of varibles of direct significance to administrative decision makers. The output of the analysis includes consideration of the costs of adminstration, acceptability to industrial firms and to state and local governments, and anticipated effectiveness in the prevention of spills of hazardous substances.

The following analysis of methodologiesfor determining harmful quantites and rates of penalty provides a semi-quantitative assessment of the adminstrative aspects associated with the implementing of hazardous material spill regulations. Methodologies are compared on a relative

TABLE VI-7

AVERAGE HARMFUL QUANTITIES BY GENERIC GROUP (lbs)*

	Lake				River				Estuary				Coastal Waters			
Group	DOHM	IMCO	ResV	UM	DOHM	IMCO	ResV	UM	DOHM	IMCO	ResV	UM	DOHM	IMCO	ResV	UM
Acids and Bases	(3) 34,468	(2) 13,146	(4) 48,211	(1) 9,655	(3) 34,408	(2) 13,146	(4) 48,211	(1) 9,655	(4) 2,883,228	(1) 11,972	(3) 31,985	(2) 18,880	(3) 2,883,228	(2) 1,312,370	(4) 4,046,802	(1) 18,880
Organic Materials	(1) 8,253	(4) 13,375	(3) 11,564	(2) 9,983	(1) 8,253	(4) 13,375	(3) 11,564	(2) 9,983	(4) 1,103,258	(1) 6,469	(3) 12,239	(2) 9,850	(3) 1,103,258	(2) 703,267	(4) 1,548,495	(1) 9,850
Detergents	(1) 1,936	(4) 7,600	(2) 2,712	(3) 5,000	(1) 1,936	(4) 7,600	(2) 2,712	(3) 5,000	(4) 67,365	(2) 3,116	(1) 747	(3) 4,100	(2) 67,365	(4) 328,000	(3) 94,551	(1) 4,100
Inorganic Gases and Liquids	(1) 4,413	(4) 9,516	(2) 6,184	(3) 7,100	(1) 4,413	(4) 9,516	(2) 6,184	(3) 7,100	(4) 614,845	(2) 10,074	(1) 6,820	(3) 16,100	(2) 614,845	(4) 1,107,900	(3) 862,976	(1) 16,100
Inorganic Salts (non-metals)	(3) 26,076	(2) 20,159	(4) 36,536	(1) 15,486	(3) 26,076	(2) 20,159	(4) 36,536	(1) 15,486	(4) 1,689,237	(1) 10,692	(3) 18,739	(2) 16,801	(3) 1,689,237	(2) 1,171,053	(4) 2,370,956	(1) 16,802
Pesticides	(3) 4,312	(2) 3,051	(4) 6,043	(1) 2,206	(3) 4,312	(2) 3,051	(4) 6,043	(1) 2,201	(4) 228,194	(1) 791	(3) 2,531	(2) 1,119	(3) 228,194	(2) 84,672	(4) 320,285	(1) 1,119
Metal Salts	(1) 4,835	(4) 8,594	(3) 6,775	(2) 6,344	(1) 4,835	(4) 8,594	(3) 6,775	(2) 6,344	(4) 1,692,327	(1) 6,161	(3) 12,117	(2) 9,570	(3) 1,092,327	(2) 672,977	(4) 1,533,159	(1) 9,570

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*For rankings in parentheses, 1 = lowest harmful quantity

TABLE VI-8

SUMMARY OF GENERAL COMPARATIVE EVALUATION

Criteria	DOHM Methodology (Rank)	IMCO Methodology (Rank)	Resource Value Methodology (Rank)	Unit of Measurement Methodology (Rank)
A. Specificity to water body type (1 = most specific)	④ Two harmful quantity and two rate of penalty categories	② Three harmful quantity and four rate of penalty categories	① Three harmful quantity and four-plus rate of penalty categories	③ One to two harmful quantity and four rate of penalty categories
B. Specificity to water body size (1 = most specific)	② Special harmful quantities for stationary sources and barges	(3-4) None	① Extrinsic adjustment factor (Loc) for penalty rate	(3-4) None
C. Specificity to physical/chemical characteristics (1 = most specific)	① Harmful quantity and rate of penalty assigned to materials individually	(3-4) Four categories for harmful quantity and base rate of penalty. Fourteen physical/chemical groups	② Harmful quantity and base rate of penalty assigned individually. General classification used for dispersion & degradability	(3-4) Same as IMCO
D. Ability to deal with mixtures (1 = greatest ability)	(3-4) None	(1-2) Within each of four categories	(3-4) None	(1-2) Within each of four categories
E. Assumptions and rationale (1 = strongest rationale)	③ Strong handling of stream and critical volume selection. Inadequate for lakes & rivers. Poor data base for setting rates of penalty	② Good data base for rates of penalty. Weak rationale for defining threshold of harm. Persistence is underrated.	① Good data for penalty rates. Weak rationale for defining threshold of harm	④ Complies with the letter of the law. Lacks underlying technical rationale and supporting data.
F. Severity of penalty rates (1 = greatest severity)	① High for major threat materials but comparatively low for many metal salts and pesticides	② Typically higher than Resource Value except for certain metal salts and pesticides	③ Relatively low for major threat mat'l.; however, extremely high for pesticides and certain metal salts	④ Uniformly lower than IMCO except in coastal waters
G. Size of harmful quantity (1 = smallest size)	② Follows same pattern as ResV methodology differing by the ratio of critical volumes	③ Typically smaller than ResV except for certain metal salts and pesticides	④ Typically large for major threat mat'l.; however, quite small for certain pesticides and metal salts	① Typically smaller than other methodologies. Substantially smaller for coastal waters.

basis since sufficient data for an absolute comparison are not available. Thus, although it concluded from this analysis that the Resource Value Methodology is the best overall approach, it remains to be determined how much better it is in relation to the other three methodologies as well as in relation to other EPA efforts to reduce pollution resulting from hazardous material spills.

Basic Approach to the Administrative Analysis

For the purposes of this analysis, the four methodologies for determination of harmful quantities and rates of penalty are viewed initially in terms of their inherent characteristics, or "direct implications" (see Table VI-8). From these implications are derived a number of "intermediate criteria". In turn, these intermediate criteria form the basis for estimates of the "output criteria". Table VI-9 displays the various direct implication categories as well as intermediate and output criteria. It also indicates the relationships among these variables.

Direct Implications

As indicated previously, the details of the direct implications of the four methodologies are contained in a preceding section on direct comparison. The results of this direct comparison are summarized in that section by relative rankings of the methodologies with respect to each criterion. The ranking factors shown in Table VI-8 are used as inputs to the intermediate and output criteria in this section.

Intermediate Criteria

The intermediate criteria considered in this analysis are listed in Table VI-9. They are derived for each of the methodologies through the aggregation procedure, individual input criteria are sometimes weighted to account for their relative importance. The results of these evaluations are then used to assign relative ranks to the various methodologies with respect to each intermediate criterion.

Inducement for Preventive Action

One of the prime objectives of the hazardous substances legislation is to cause handlers of hazardous substances to take measures to prevent discharges of these materials to the environment. In the present analysis, handlers of hazardous substances are considered to be responsive to the following direct implication variables:

TABLE VI-9

SUMMARY OF INPUT, INTERMEDIATE AND OUTPUT CRITERIA

Input Criteria	Intermediate Criteria (inputs)	Output Criteria (inputs)
A. Specificity to Water Body Type	1. Inducement for Preventive Action (A, B, C, D, F, G)	I. Staff and Equipment Costs (1, 2)
B. Specificity to Water Body Size	2. Ease of Technical Application (A, B, C)	II. Litigation and Negotiation Costs (4)
C. Specificity to Chemical Groups	3. Equitability of Treatment (A, B, C, D, E)	III. Ease of Administration (1, 2, 3, 4, 5)
D. Ability to Deal With Mixtures	4. Likelihood of Avoiding Legal Challenges (A, B, C, D, E, F, G)	IV. Acceptability to Industry (F, G, 3, 5)
E. Assumptions and Technical Rationale	5. Adaptability to Change (A, B, C, D, E)	V. Acceptability to Local Government (1, 3, 5)
F. Severity of Penalty		VI. Acceptability to State Government (1, 3, 5)
G. Size of Harmful Quantity		VII. Administrative Effectiveness (1, 4, 5)

- Input Variable A - Specificity to Water Body Type
- Input Variable B - Specificity to Water Body Size
- Input Variable C - Specificity to Chemical Groups
- Input Variable D - Ability to Deal With Mixtures
- Input Variable F - Severity of Penalty Schedule
- Input Variable G - Size of Harmful Quantity

The specificity variables and the ability of a methodology to deal with mixtures are considered to affect the inducement for preventive action by tailoring the penalty schedule to the specific set of circumstances surrounding a hazardous material spill. The more specific the methodology, the less likely that chemicals or spillers can slip into a loophole where they will not be subject to adequate penalties. Specificity also provides inducement to locate in less sensitive areas. At the same time, a high degree of specificity will make firms or individuals who handle hazardous substances less resistant to the idea of a penalty schedule. They will not be likely to consider that they as individuals are being treated unfairly relative to other firms or individuals.

As important as the specificity criteria are, it is likely that the severity of the penalty schedule will have a stronger impact upon the decisions of potential spillers of hazardous substances to act to prevent such spills. Assuming as a constraint that no penalty schedule will be implemented which threatens the viability of any significant number of firms, it follows that the higher the penalty schedule is, the greater will be the tendency to prevent spills. Low harmful quantities will have a similar effect vs. higher, less restrictive harmful quantities.

Following the above rationale, the four methodologies for determining harmful quantities and rates of penalty can be compared as shown in Table VI-10. Note in the table the Variable F - Severity of Penalty Schedule has been weighted at twice the value of other direct inputs.

Ease of Technical Application

Specificity is highly desirable in a methodology for several reasons, but it is achieved only at a cost. The more specific a methodology is, the greater the information necessary to apply the methodology. Highly specific methodologies will

TABLE VI-10

RANKING OF METHODOLOGIES WITH RESPECT TO INTERMEDIATE VARIABLE 1 - INDUCEMENT FOR PREVENTIVE ACTION

Methodology	Ranks for Relevant Direct Variables (weighting factors) Var A (1)	Var B (1)	Var C (1)	Var D (1)	Var F (2)	Var G (1)	Sum of Direct Implication Ranks	Rank Score for Intermediate Variable 1[a]
DOHM	4	2	1	3.5[b]	2	2	14.5	1
IMCO	2	3.5[b]	3.5[b]	1.5[b]	4	3	17.5	2-3
RV	1	1	2	3.5[b]	6	4	17.5	2-3
UM	3	3.5[b]	3.5[b]	1.5[b]	8	1	20.5	4

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[a] 1 = greatest inducement.

[b] Tie rank scores (e.g., 3-4) are indicated as decimals (e.g., 3.5) for computational purposes.

require substantially greater post-spill investigations than will less specific methodologies, and these investigations will require highly trained individuals and expensive instrumentaion. At the same time, handlers of hazardous substances will need greater information in order to determine when they must report spills. They will also need to keep more detailed records as substantiation for actual or potential spills. In effect, high specificity results in relatively high implementation costs for both hazardous substance handlers and public officials charged with implementing hazardous substance regulations.

In this study, the ease of technical application is considered to be equally responsive to each of the following direct implication variables:

- Input Variable A - Specificity to Water Body Type
- Input Variable B - Specificity to Water Body Size
- Input Variable C - Specificity to Chemical Groups.

The ranking of the four methodologies with respect to ease of technical application is shown in Table VI-11.

TABLE VI-11

RANKING OF METHODOLOGIES WITH RESPECT TO INTERMEDIATE VARIABLE 2 - EASE OF TECHNICAL APPLICATION

	Ranks for Relevant Direct Implication Variables				
Methodology	Var A	Var B	Var C	Sum of Direct Implication Ranks	Rank Score for Intermediate Variable 2[a]
DOHM	4	2	1	7	3
IMCO	2	3.5[b]	3.5[b]	9	2
RV	1	1	2	4	4
UM	3	3.5[b]	3.5[b]	10	1

---

[a] 1 = greatest ease of technical application.

[b] Tie rank scores (e.g., 3-4) are indicated as decimals (e.g., 3.5) for computational purposes in this table.

Equitability of Treatment of Discharges

In considering the relative worth of the four methodologies in this study, it is necessary to make an explicit comparison of the degree to which various parties would be treated fairly under the methodologies. Herein, equitability is deemed to be equally responsive to each of the following direct implication variables:

- Input Variable A - Specificity to Water Body Type
- Input Variable B - Specificity to Water Body Size
- Input Variable C - Specificity to Chemical Groups
- Input Variable D - Ability to Deal With Mixtures
- Input Variable E - Assumptions and Technical Rationale.

Variables A-D, the "specificity" variables, are important to equitability for the reasonsdiscussed above in connection with Inducement for Preventive Action. Variable E - Assumtion and Technical Rationale is considered to be twice as important as Variables A through D. Assumptions which oversimplify the hazards of designated substances may result in inequitable penalization of potential spillers. Additionally, if rationale of questionable validity are used to support the development of a methodology, errors in these rationale may be beneficial to some handlers and detrimental to others.

TABLE VI-12

RANKING OF METHODOLOGIES WITH RESPECT TO INTERMEDIATE VARIABLE 3--EQUITABILITY OF TREATMENT OF INVOLVED PARTIES

Methodology	Ranks for Relevant Direct Implication Variables (weighting factors) Var A (1)	Var B (1)	Var C (1)	Var D (1)	Var E (2)	Sum of Direct Implication Ranks	Rank Score for Intermediate Variable 3[a]
DOHM	4	2	1	3.5[b]	6	16.5	3
IMCO	2	3.5[b]	3.5[b]	1.5[b]	4	14.5	2
RV	1	1	2	3.5[b]	2	9.5	1
UM	3	3.5[b]	3.5[b]	1.5[b]	8	19.5	4

---

[a] 1 = greatest degree of equitability.

[b] Tie rank scores (e.g., 1-2) are indicated as decimals (e.g., 1.5) for computational purposes.

Likelihood of Avoiding Legal Challenges

In the following analysis, it is assumed that questions of constitutionality of the basic hazardous substance legislation and the right of the federal government and designated agencies to implement the legislation will not come up in legal challenges. Given this assumption, the likelihood of avoiding legal challenges in the implementation of the hazardous substance legislation will be dependent in large part upon the equitability of the methodology used in establishing penalty schedules -- as perceived by hazardous substance handlers. Challenges might also be based specifically upon the validity of the assumptions and rationale supporting the methodology. The degree to which affected individuals and firms seek to make such challenges, however, will be dependent upon the severity of the penalty schedule.

In accordance with the above discussion, the likelihood of avoiding legal challenge is considered here to be responsive to the following direct implication variables:

- Input Variable A - Specificity to Water Body Type
- Input Variable B - Specificity to Water Body Size
- Input Variable C - Specificity to Chemical Groups
- Input Variable D - Ability to Deal With Mixtures
- Input Variable E - Assumptions and Technical Rationale
- Input Variable F - Severity of the Penalty Schedule (inverse)
- Input Variable G - Size of Harmful Quantity (inverse).

Variables E and F are considered to be more important in determining the likelihood of challenge and hence these variables have been assigned weighting factors of 2. Table VI-13 presents the ranking of the four methodologies on the basis of this intermediate variable.

Adaptability to Changes in Technical Criteria, Standards, and Hazardous Substance Listings

Regulation of hazardous substances is a relatively new undertaking. There can be little doubt that numerous changes will be made in technical criteria, standards, and hazardous substance listings. Accordingly, it is very important that any methodology selected for use in determining harmful quantities and rates of penalty be readily adaptable to such changes.

As viewed here, adaptability to changes is responsive equally to each of the following direct implication variables:

- Input Variable A - Specificity to Water Body Type
- Input Variable B - Specificity to Water Body Size
- Input Variable C - Specificity to Chemical Groups
- Input Variable D - Ability to Deal With Mixtures
- Input Variable E - Assumptions and Technical Rationale.

Since changes may occur in some factors while others remain unaltered, highly specific methodologies will tend to be more readily adaptable to these changes than relatively unspecific methodologies. Changes can be made in the affected aspects of the highly specific methodologies while leaving the other aspects intact; changes in the unspecific methodologies would tend to affect large portions of the methodologies if the changes could be made at all.

Where assumptions supporting methodologies are arbitrary, they cannot be sensitive to many kinds or degrees of changes. Similarly, methodologies based upon rationale of questionable validity cannot be meaningfully adjusted since the margin of error is likely to be large relative to the magnitude of desired adjustment.

Table VI-14 presents the rankings of the four methodologies with respect to adaptability to changes in technical criteria, standards, and hazardous substance listings.

Summary of Intermediate Criteria

Table VI-15 presents a summary of the rankings of the four methodologies with respect to the five intermediate criteria.

Output Criteria

The four methodologies considered in this study are evaluated in terms of the output criteria in a manner similar to that used for evaluating them in terms of the intermediate criteria. The result is a set of relative rankings of the four methodologies regarding each output criterion.

TABLE VI-13

RANKING OF METHODOLOGIES WITH RESPECT TO INTERMEDIATE VARIABLE 4 - LIKELIHOOD OF AVOIDING LEGAL CHALLENGES

	Ranks for Relevant Direct Implication Variables (weighting factors)								
Methodology	Var A (1)	Var B (1)	Var C (1)	Var D (1)	Var E (2)	Var F[a] (2)	Var G[a] (1)	Sum of Direct Implication Ranks	Rank Score for Intermediate Variable 4[b]
DOHM	4	2	1	3.5[c]	6	8	3	27.5	4
IMCO	2	3.5[c]	3.5[c]	1.5[c]	4	6	2	22.5	2
RV	1	1	2	3.5[c]	2	4	1	14.5	1
UM	3	3.5[c]	3.5[c]	1.5[c]	8	2	4	22.5	3

---

[a] Due to the inverse relationship between this variable and the likelihood of avoiding legal challenge, the rankings for this variable are converted for use in this table by subtracting each score from 5.

[b] 1 = least likelihood of legal challenge.

[c] Tie rank scores (e.g., 1-2) are indicated as decimals (e.g., 1.5) for computational purposes.

TABLE VI-14

RANKING OF METHODOLOGIES WITH RESPECT TO VARIABLE 5 - ADAPTABILITY TO CHANGES

Methodology	Ranks for Relevant Direct Implication Variables					Implication Ranks	Rank Score for Intermediate Variable 5[a]
	Var A	Var B	Var C	Var D	Var E		
DOHM	4	2	1	3.5^b	3	13.5	3
IMCO	2	3.5^b	3.5^b	1.5^b	2	12.5	2
RV	1	1	2	3.5^b	1	8.5	1
UM	3	3.5^b	3.5^b	1.5^b	4	15.5	4

---

[a] 1 = greatest adaptability to changes.

[b] Tie rank scores (e.g., 1-2) are indicated as decimals (e.g., 1.5) for computational purposes in this table.

TABLE VI-15

SUMMARY OF INTERMEDIATE CRITERIA

Variable Number	Intermediate Criterion	Relative Rankings			
		DOHM	IMCO	RV	UM
1.	Inducement for Preventive Action (1 = greatest inducement for preventive action)	1	2.5	2.5	4
2.	Ease of Technical Application (1 = greatest ease of technical application)	3	2	4	1
3.	Equitability of Treatment of Involved Parties (1 = greatest equitability of treatment)	3	2	1	4
4.	Likelihood of Avoiding Legal Challenges (1 = greatest likelihood of avoiding legal challenges)	4	2	1	3
5.	Adaptability to Changes (1 = greatest adaptability to changes)	3	2	1	4

Staff and Equipment Costs

Staff and equipment costs are considered in this analysis to be equally responsive to each of the following variables:

- Intermediate Variable 1 - Inducement for Preventive Action
- Intermediate Variable 2 - Ease of Technical Application.

In general, the greater the inducement for preventive action on the part of individuals or firms handling hazardous substances, the smaller the requirement for public officials to deal with actual spills. On the other hand, methodologies which are difficult to apply may require more officials to implement them. Furthermore, these officials may need to be highly trained and to be equipped with expensive, sophisticated instruments.

Table VI-16 presents the rankings for the four methodologies with respect to staff and equipment costs.

Litigation and Negotiation Costs

In this analysis, litigation and negotiation costs are only responsive to Intermediate Variable 4 - Likelihood of Avoiding Legal Challenges. Hence this output variable is equalled to Intermediate Variable 4. The development of the rankings for this intermediate variable is presented in the preceding section.

Ease of Administration

Ease of administration connotes considerations of administrative costs. However, in this analysis it also reflects other variables. Those intermediate criteria areas involved follow:

- Intermediate Variable 1 - Inducement for Preventive Action
- Intermediate Variable 2 - Ease of Technical Application
- Intermediate Variable 3 - Equitability of Treatment of Involved Parties
- Intermediate Variable 4 - Likelihood of Legal Challenges

TABLE VI-16

RANKING OF METHODOLOGIES WITH RESPECT TO OUTPUT VARIABLE I - STAFF AND EQUIPMENT COSTS

Methodology	Ranks for Relevant Intermediate Criteria		Sum of Intermediate Criteria Ranks	Rank Score for Output Variable I[a]
	Var 1	Var 2		
DOHM	1	3	4	1
IMCO	2.5	2	4.5	2
RV	2.5	4	6.5	4
UM	4	1	5	3

---

[a] 1 = lowest expected cost

- Intermediate Variable 5 - Adaptability to Changes.

Methodologies which provide a high degree of inducement for preventive action tend to minimize the need for administrative work. Those which are relatively easy to apply from a technical point of view minimize administrative difficulty by minimizing the needs to search for details and to maintain extensive data files. Equitability and likelihood of legal challenges affect the ease of administration by indicating the extent to which administrative efforts might be hindered by negotiations and litigation. Finally, adaptability considerations are relevant because of the expected need to accomodate frequent changes in technical criteria, standards, and hazardous substance listings.

Rankings for the four methodologies resulting from consideration of these factors as they affect ease of administration are presented in Table VI-17.

Acceptability to Industry

The acceptability of a methodology to industry is viewed in the present study as responsive to the following variables:

- Direct Input Variable F - Severity of Penalty Schedule (inverse)
- Direct Input Variable G - Size of Harmful Quantity (inverse)
- Intermediate Variable 3 - Equitability of Treatment of Involved Parties
- Intermediate Variable 5 - Adaptability to Changes.

The sensitivity of industrial firms to the severity of the penalty schedule and harmful quantity is readily understood and has been discussed earlier in this report. Similarly, industrial concern with equitability has been discussed in earlier portions. Finally, since some adjustments in the hazardous substances regulations (made in response to changes in technology) might favor the interests of industry, firms have reason to prefer methodologies which are adaptable. Variables F and 3, Severity of the Penalty Schedule and Equitability, are probably of greater importance to industrial firms than are Variables G and 5; hence, the former two variabales have been assigned a weighting factor of 2.

TABLE VI-17

RANKING OF METHODOLOGIES WITH RESPECT TO OUTPUT VARIABLE III - EASE OF ADMINISTRATION

Methodology	Ranks for Relevant Intermediate Criteria					Sum of Intermediate Criteria Ranks	Rank Score for Output Variable III[a]
	Var 1	Var 2	Var 3	Var 4	Var 5		
DOHM	1	3	3	4	3	14	3
IMCO	2.5	2	2	2	2	10.5	2
RV	2.5	4	1	1	1	9.5	1
UM	4	1	4	3	4	16	4

---

[a] 1 = easiest to administer

Table VI-18 presents the rankings for the four methodologies with respect to acceptability to industry.

Acceptability to Local Government

In some respects, local government is sensitive to the same variables discussed for industry, and for largely the same reasons. It is not in the interest of local government to allow industrial firms to become dissatisfied with the circumstances in which they operate, especially if these circumstances vary from one location to another. In addition, however, local government is interested in achieving adequate control of hazardous substances to prevent destruction of the environment or risks to human health. Accordingly, in this analysis, acceptability to local government is considered equally responsive to the following variables:

- Intermediate Variable 1 - Inducement for Preventive Action
- Intermediate Variable 3 - Equitability of Treatment of Involved Parties
- Intermediate Variable 5 - Adaptability to Changes.

Table VI-19 presents the rankings for the four methodologies with respect to acceptability to local government.

Acceptability to State Government

Though threatened somewhat less directly by the consequences of industrial firm dissatisfaction than local government, the state governments are responsive to the same variables as the local governments and in essentially the same way. Consequently, the rankings and the supporting rationale for the rankings of the four methodologies are the same with respect to local and state governments.

Effectiveness

Administrative effectiveness is a measure, in this analysis, of the extent to which administration of the hazardous substances regulation program is successful in preventing the discharge of hazardous substances into the environment. It is considered equally responsive to the following variables:

- Intermediate Variable 1 - Inducement for Preventive Action
- Intermediate Variable 4 - Likelihood of Avoiding Legal Challenges

TABLE VI-18

RANKING OF METHODOLOGIES WITH RESPECT TO OUTPUT VARIABLE IV - ACCEPTABILITY TO INDUSTRY

Methodology	Ranks for Relevant Variables (weighting factor) Var F[a] (2)	Var G[a] (1)	Var 3 (2)	Var 5 (1)	Sum of Ranks for Relevant Variables	Rank Score for Output Variable IV[b]
DOHM	8	3	6	3	20	4
IMCO	6	2	4	2	14	2
RV	4	1	2	1	8	1
UM	2	4	8	4	18	3

---

[a] In order to make the rankings for this variable comparable with the others in this analysis (i.e., 1 = greatest acceptability to industry), the rankings for this variable are converted for use in this table by subtracting each score from 5.

[b] 1 = most acceptable to industry

TABLE VI-19

RANKING OF METHODOLOGIES WITH RESPECT TO OUTPUT VARIABLE V - ACCEPTABILITY TO LOCAL GOVERNMENT

Methodology	Ranks for Relevant Variables			Sum of Ranks for Relevant Variables	Rank Score for Output Variable V[a]
	Var 1	Var 3	Var 5		
DOHM	1	3	3	7	3
IMCO	2.5	2	2	6.5	2
RV	2.5	1	1	4.5	1
UM	4	4	4	12	4

---

[a] 1 = most acceptable to local government

- Intermediate Variable 5 - Adaptability to Changes.

Inducement of preventive action is of obvious importance. Legal challenges must be minimized in order that the resources available to the private and public sectors can be devoted to preventing hazardous material spills. It is also important that no legal challenge occur which might result in a legal ruling disallowing the program entirely. Adaptability is important to prevent the gradual deterioration of the regulation program over time as conditions and needs change.

Rankings for the four methodologies with respect to administrative effectiveness are presented in Table VI-20.

Summary of Output Criteria

Table VI-21 presents a summary of the rankings of the four methodologies with respect to the seven output criteria. From this table, it is clear that the Resource Value Methodology is the most desirable one in all areas except staff and equipment costs. This follows since it is logical that the most effective methodology would be one requiring greater efforts on the part of the regulatory agency.

TABLE VI-20

RANKING OF METHODOLOGIES WITH RESPECT TO OUTPUT VARIABLE VII - ADMINISTRATIVE EFFECTIVENESS

Methodology	Ranks for Relevant Variables			Sum of Ranks for Relevant Variables	Rank Score for Output Variable VII[a]
	Var 1	Var 4	Var 5		
DOHM	1	4	3	8	3
IMCO	2.5	2	2	6.5	2
RV	2.5	1	1	4.5	1
UM	4	3	4	11	4

---

[a] 1 = greatest administrative effectiveness

TABLE VI-21

SUMMARY OF OUTPUT CRITERIA

Variable Number	Output Criterion	Relative Rankings DOHM	IMCO	RV	UM
I	Staff and Equipment Costs (1 = minimum costs)	1	2	4	3
II	Litigation and Negotiation Costs (1 - minimum costs)	3	2	1	4
III	Ease of Administration (1 = maximum ease of administration)	3	2	1	4
IV	Acceptability to Industry (1 = maximum acceptability)	4	2	1	3
V	Acceptability to Local Government (1 = maximum acceptability)	3	2	1	4
VI	Acceptability to State Government (1 = maximum acceptability)	3	2	1	4
VII	Administrative Effectiveness (1 = maximum effectiveness)	3	2	1	4

VII. SPECIAL ISSUES

BRIEF

During the course of this evaluation, it became apparent that certain special issues falling outside the context of a comparative analysis needed to be addressed. These issues will have a bearing on any regulation developed to comply with Section 311. As such, they should be reviewed prior to selection of a technical approach. The pertinent issues fall into three categories: insurability, jurisdiction and litigation, and compliance with congressional intent.

INTRODUCTION

The Water Quality Improvement Act (PL 91-224) and the Water Pollution Control Act (PL 92-500) were primarily designed to protect the rights of every individual from the harmful effects of water pollution. Through the determination and administration of the Environmental Protection Agency, violators of Section 311 of the latter law will be subjected to both clean-up costs and civil penalties based on the toxicity, degradability, and dispersal characteristics of spilled materials. Pertinent to the civil penalties, PL 92-500 stipulates that the owner of any vessel, onshore facility, or offshore facility, from which there is a discharge of any hazardous materials determined not removable, and not caused by an act of omission in combination with an act of God, nor an act of war, nor negligence on the part of the United States government, will be liable for a civil penalty not to exceed $5,000,000 from a hazardous spill due to a vessel, or $500,000 from a hazardous spill originating from an onshore or offshore facility.

Owners and operators must prove financial responsibility for the clean-up costs and civil penalties arising from PL 92-500 before the operation of any vessel, onshore facilities, or offshore facilities that are potentially hazardous to water resources. Financial responsibility for property damage and other liabilities has traditionally been provided by the insurance industry. This section examines the modern insurance associations formed to underwrite the risk of water pollution. Through an examination of the United States insurance market and the London insurance market a response can be determined as to what future position will be taken on the underwriting of direct water pollution risks stemming from operating in accordance of PL 92-500.*

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*The combined United States and London Insurance markets underwrite 85 percent of the world's commercial liability coverage.

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BACKGROUND

Under the Water Quality Improvement Act of 1970 (PL 91-224), the forerunner of the Federal Water Pollution Control Act of 1972 (PL 92-500), spilling oil in harmful quantities into or upon the navigable waters of the United States and adjoining shorelines was prohibited. Furthermore, this statute imposed liability on all vessels or boat owners for oil pollution clean-up costs incurred by the United States government. This liability was based upon $100 per gross ton of the vessel, or $14,000,000, whichever was the lesser. PL 92-500 has extended the Water Quality Improvement Act to cover hazardous substances along with oil.

Pending designation of specific hazardous materials by the U. S. Environmental Protection Agency, however, enforcement of spill regulations for the last two years has been directed to oil spills and has involved a civil penalty limit of $50,000. As of October 18, 1974, that limit is no longer operable. Consequently, enforcement is proceeding under the 1899 Refuse Act until a period within 180 days of the date of designation at which time the $500,000 and $5,000,000 maximum liabilities will come into force.

Key elements in assessing the likely response of the insurance industry are:

- Federal Maritime Commission
- Water Quality Insurance Syndicate
- Protection and Indemnity Clubs
- Radioactive Substances
- Onshore and Offshore Facilities.

These items are individually discussed below.

FEDERAL MARITIME COMMISSION

On August 3, 1973, President Nixon delegated to the Federal Maritime Commission the responsibility to administer the financial responsibility requirements imposed by PL 92-500. Under the proposed FMC rules, financial responsibility for payment of clean-up costs and civil penalties must be shown by filing an application form (FMC-321) supported by certificates of insurance (FMC-322). No vessel is allowed to operate in the United States or its territories without FMC certification.

FMC-321 requires that proof of financial responsibility be shown by operators or owners by either showing self insurance, or by being insured by a reputable underwriter. Since the Commission will accept an insurance polity as evidence of financial responsibility, underwriters feel that most vessel owners have found this procedure the least time-consuming and least expensive. Also, many large marine underwriters have Master FMC certificates. For the entity seeking marine insurance, this serves as an instant FMC certificate upon the purchase of the insurance.

WATER QUALITY INSURANCE SYNDICATE

In response to PL 91-224, the insurance companies which comprise virtually the entire American marine insurance market formed an insurance pool -- the Water Quality Insurance Syndicate (WQIS).

The Water Quality Insurance Synidcate is an association of 27 private insurance companies of which no one company has more than 5 percent interest in the total syndicate (see Table VII-1). The WQIS provides the capacity of insure high risks for pollution on a pool basis. Most of the syndicate's business comes from coastal tugs and barges and from ships using the inland water system. A quarter of its business is written on ocean going vessels.

The purpose of the WQIS is to provide the insurance necessary for vessel owners and operators to show financial responsibility for impingements against PL 91-224. The WQIS has been underwriting pollution insurance up to a limit of $14,000,000 or $100 per gross ton of the vessel, whichever is lesser, for clean-up costs which may be imposed by the Department of the Interior or any state of the United States. The WQIS has also underwritten up to $50,000 for civil penalties due to hazardous material spills.[1]

The WQIS handles most of the pollution insurance written in the United States. Their rates are competitive both at home and internationally. Since they underwrite most of the pollution insurance in the United States, they are the price leader in the American segment of the industry (see Table VII-2).

A representative of a large insurance syndicate handling most of the pollution insurance written in the United States was interviewed to assess the reaction to the possibility of underwriting the $5,000,000 civil penalty that may fall upon shippers for spills after the effective date of October 18, 1974. When

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[1] Louis, F. A. "Water Quality Insurance Syndicate," addressed before the Houston Marine Seminar, October 1971.

TABLE VII-1

SUBSCRIBERS TO THE WATER QUALITY INSURANCE SYNDICATE[2]

Subscriber	Percent of Pool
The Aetna Casualty and Surety Company, Hartford, CT	5.0
Aetna Insurance Company, Hartford, CT	3.0
Albany Insurance Company, New York, NY	1.0
American Home Assurance Company, New York, NY	5.0
American Motorists Insurance Company, Chicago, IL	1.5
Arkwright-Boston Manufacturers Mutual Insurance Company, Waltham, MA	5.0
Atlantic Mutual Insurance Company, New York, NY	4.0
Commercial Union Insurance Company, Boston, MA	2.5
The Continental Insurance Company, New York, NY	5.0
Emmco Insurance Company, South Bend, IN	2.0
Federal Insurance Company, Short Hills, NJ	2.5
Fireman's Fund Insurance Company, San Francisco, CA	5.0
The General Insurance Company of Trieste & Venice, U. S. Branch, New York, NY	1.0
Great American Insurance Company, New York, NY	2.5
Hartford Fire Insurance Company, Hartford, CT	5.0
Highlands Insurance Company, Houston, TX	5.0
The Home Insurance Company, Manchester, NH	5.0
Insurance Company of North America, Philadelphia, PA	5.0
The New Zealand Insurance Company, Limited, U. S. Branch, San Francisco, CA	1.5
National Fire Insurance Company of Hartford, Hartford, CT	3.0
Northwestern National Insurance Company, Milwaukee, WI	4.0
Reliance Insurance Company, Philadelphia, PA	2.5
Royal Insurance Company, Limited, U. S. Branch, New York, NY	5.0
St. Paul Fire and Marine Insurance Company, St. Paul, MN	5.0
Sun Insurance Company of New York, New York, NY	4.0
United States Fidelity & Guaranty Company, Baltimore, MD	5.0
United States Fire Insurance Company, New York, NY	5.0
Total	100.0

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[2] Correspondence with WQIS, September 1974 (also available in Best's Insurance Guide).

TABLE VII-2

PREMIUM RATES FOR POLLUTION INSURANCE SET BY THE WATER QUALITY INSURANCE SYNDICATE[2]

Category	Type of Vessel	Minimum Premium*	Rate
A	Vessels carrying oil as cargo	$375	75¢/gross ton
B	Vessels carrying hazardous substances as cargo	400	80¢/gross ton
	Except if hazardous substance is determined removable as established by the EPA	375	75¢/gross ton
C	Tugs and towboats (if over 100 gross ton)	250	50¢/gross ton
	" (if under 100 gross ton)	100	
D	Self-propelled vessels (excluding A, B, and C) trading exclusively within U. S. navigable waters		
	(if over 100 gross ton)	200	40¢/gross ton
	(if under 100 gross ton)	100	
E	Other self-propelled vessels (excluding categories A, B, and C)		(given upon application)
F	Non-self-propelled vessels (excluding A and B)		25¢/gross ton
	(if over 100 gross ton)	125	
	(if under 100 gross ton)	100	

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*All premiums are for annual policies.

asked if WQIS is likely to extend their coverage to maintain civil penalty, the representative responded:

> "Definitely not. There is no question that we are interested in our share of the market, but we are also interested in staying in business. Coverage for the $50,000 civil penalty was just barely extended to shippers. There is no chance of us underwriting any more than $50,000 for civil penalties."

Additionally, the representative noted that:

> "The effect of 92-500 in its present state will be to put some of the small shippers out of business or to stop shipping altogether. The effect of the Florida Water Quality Law was to increase by four times the price of oil in Florida. Everyone was afraid to go into Florida for fear of paying those outrageous penalty costs. Who really paid the cost? Anyone down there who needed to heat their home or needed oil for any purpose. It will be the same with this law. Unless the law is more realistic, I can see the cost being carried by you and me."[7]

The point raised by the insurance industry on specific state laws bears thought. Along with being subjected to Federal Laws which may lead to a civil penalty, shippers, vessel owners, offshore and onshore installations have to comply with state regulations or face additional civil penalties. The Florida Act requires that a vessel, even though it has satisfied the financial responsibility requirements of the Federal Act insofar as trading to the United States ports were concerned, would be obliged to give additional evidence of financial responsibility to the Florida authorities. The Florida Act imposed absolute and unlimited liability. Since there was no insurance available, shippers could not give the required evidence and, therefore, could not trade. During the past few months it has become clear that the Florida legislature will have to do something with respect to its legislation.[1]

The New York assembly is currently considering several pieces of legislation which deeply concern the insurance industry: Assembly Acts 9954, 9966, and 10452(a). Many insurers feel that laws such as these are an overreaction in the name of ecology. A consensus shows that most of the spokesmen for the insurance industry feel that punitive legislation does not prevent hazardous spills or threats to ecological structure, but will terminate shipping activities since insurance coverage will not be extended.

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[1] Interview with Gordon Paulsen, Haight, Gardner, Poor and Havens, New York, New York, September 5, 1974.

PROTECTION AND INDEMNITY CLUBS

A large share of the property and liability insurance has been written by the London Property and Industry Clubs (P & I Clubs). (The word "clubs" is simply a term handed down from many years ago based upon an association of shipowners getting together as a "club" to mutually insure one another's risks; those risks which were not covered by hull insurance but which were imposed by the laws of the various countries to which the vessels traded.) The London P & I Clubs are by far the largest and most influential. They are organizationally associated with members from England, Norway, Sweden, Japan, Bermuda, and Luxembourg.

Gordon W. Paulsen,[3] the attorney representing the London Clubs in the United States, has stated that the P & I Clubs will offer moderate coverage up to and including the recent limits of the law, or a civil penalty maximum of $50,000. However, he could not see anyone in the world underwriting $5,000,000 for punitive damages. He further noted that in his opinion, civil penalties, or punitive costs, do not and will not prevent the incidence of hazardous material spills.

RADIOACTIVE SUBSTANCES

Radioactive materials were not included in the advance list of hazardous substances designated by the Environmental Protection Agency. However, the EPA has specified that radioactive substances may be considered in the future.

During 1972 a total of 13,256 tons of radioactive material (including associated materials and wastes) were transported over navigable U. S. waters. Of that amount, just over 10,000 tons were international movements (6,000 import and 4,000 export) and 3,209 tons were domestic (2,811 tons on inland waterways and 398 tons in coast-wide traffic).*

The transport of radioactive materials in the United States (all modes) has not led to death or physical injury in twenty-five years. The insurance industry categorizes the property damage from radioactive transport as "extremely low." Damages have been kept to a minimum because of the severe packaging rules

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*Statistics concerning radioactivity were provided by the insurance industry.

(administered by the Department of Transportation) that have been implemented in radioactive transportation. Generally, the packing design and construction must provide for "no significant" release to the environment and the effectiveness of this packing cannot be reduced in transit. When moving more than token amounts (about three curies), it is also required that the packing withstand hypothetical accidental conditions; i.e., the criteria is that the package must not release any radioactive material if exposed to the severest strains of the particular transport path. The possible spill of a radioactive substance (escape from its transportation containment system) is remote.

Radioactive substances have a proven safe transport record, primarily because of the mystique associated with the substance itself in the last two decades. And yet, while the P & I Clubs and Lloyds are noted internationally for insuring high risks, both have been hesitant in the past about underwriting anything having to do with radioactive substances. This attitude may well prevail for hazardous materials in general.

CONCLUSIONS ON INSURABILITY

The problem of developing a program to prevent the incidence of water pollution by public policy (in this case, PL 92-500) lies in the determination of the responsibility of potential spillers to society. If left unpolluted, clean water represents a social value enjoyed by everyone. However, if pollution of water resources is left unchecked, this social benefit can very quickly be transformed into a social cost.

The underlying problem with which this section is concerned involves determining who is going to be responsible and pay for harmful actions against society. This section examined the insurance industry and determined the extent of risks that they are willing to assume based on water pollution.

With respect to PL 92-500, a consensus of insurance underwriters indicates that coverage for water pollution will not be extended beyond $50,000 for civil penalties and $14,000,000 for clean-up costs. The consensus represents a large sample of the worldwide market. It is the feeling of the insurance industry that civil penalties are not going to reduce hazardous spills. Also, if the hazardous spill were caused by negligence, and if the civil penalty were based on negligence, the insurance industry will not take responsibility for a punitive cost due to carelessness.

JURISDICTION AND LITIGATION

There are two other special issues deserving comment: the interface of regulations promulgated by various authorities, and the complexities of litigation in assessing civil penalties. The former refers to past and present efforts by state, Federal, and international bodies to control the discharge of materials into the sea. Many times, these efforts are duplicative and/or contradictory in nature. At other times, they prove to be excessively restrictive. The example of the State of Florida has already been stated. Many other states also maintain various laws and regulations on marine pollution.

International activities began with the 1954 Convention for the Prevention of Pollution of the Sea by Oil. The inter-Governmental Maritime Consultative Organization (IMCO) now spearheads efforts in this area and has expanded in scope to consider hazardous materials. Recent developments include two new conventions: The Intervention Convention, and The Convention on Civil Liability for Oil Pollution Damage. The former ratified by the United States is pertinent to oil in that it gives national governments the right to take drastic measures, even on the high seas, when the threat of dangerous pollution is imminent.

It is likely that international conventions will not lead to the complications evident from state regulations. This is due largely to the fact that international conventions must be ratified by member countries and have typically been modified to meet the desires of the participants. State regulations, however, may differ greatly from Federal ones. Indeed, when the three judge federal court in Florida struck down the Florida statute on the grounds that it violated the principle that admiralty law should be uniform, the Supreme Court took exception. At that time, it was asserted that many of the law's provisions could be maintained including those imposing unlimited clean-up liability. The nature of the problem resulting from this type of allowance is more clear when it is realized that there are presently three state statutes in force, and other actions being planned. The combined effect of multiple civil liabilities and varying maximum liability limits has served to overwhelm shippers and frighten off insurers.

The preceding comments reflect the operating difficulties faced by industry. It would be remiss not to mention similar enforcement difficulties facing the regulatory agency. The bulk of these stem from the litigation aspects of assessing civil penalties and are most clearly demonstrated in a recent case in Louisiana. In United States vs LeBouf Bros. Towing Co., F. Supp. (E. D. La. 1974) the court held that civil penalties could not be assessed solely on the basis of information received in the initial report from the discharger. Rather, independently derived information was necessary to avoid claims of "self-incrimination." An abstract of this case is included here as Exhibit A.

EXHIBIT A

UNITED STATES VS LE BEOUF
BROTHERS TOWING COMPANY
(377 F. Supp. 558, 1974)
(E. D. La. June 14, 1974)
Brief Abstract of Case

FACTS:

1) The United States Coast Guard notified the defendant (Le Beouf) that the government proposed a penalty of $3,000 under Section 1161 (b) (5) of the Water Pollution Control Act against Le Beouf due to gasoline spillage that occurred on approximately June 3, 1972.[1]

2) Just shortly after the United States Coast Guard hearing convened, the penalty that had been assessed was compromised to $2,500.

3) Le Beouf denied the propriety of the penalty owed the United States and the United States Coast Guard referred the matter to the United States Attorney who filed the lawsuit to collect the $2,500 penalty.

4) Le Beouf complied with the notification proviso upon discovery of the gasoline spillage and argues that said self-disclosure provided the United States Coast Guard with sufficient data by which the Coast Guard could substantiate the so-called "civil penalty" subsequently assessed against the defendant.

5) Le Beouf maintains that this type of connexity between Sub part (b) (4) of §1161 and Title 33, U. S. Code, §1161 (b) (5) (See Footnote 1) makes both criminal in nature and invalidates Paragraph 5 as being unconstitutional, and, the defendant has incorporated this logic into a motion to dismiss and/or for summary judgement.[2]

LEGAL POSTULATE OF DEFENSE:

1) Paragraph 5 of the Water Pollution Control Act although stating "civil penalty" prescribes criminal penalty and ergo is penal, and not a remedial provision.

2) The immunity granted in Paragraph 4 must extend to cover Paragraph 5, since, to do otherwise would abrogate constitutional protections afforded by the 5th, 6th, and 14th amendments to the United States Constitution, and thus unduly circumscribe statutory immunity as it is stated in Paragraph 4.

B) This is a complete denigration of the statutory purpose in fostering self-disclosure -- ONE WOULD FACE PUNITIVE SANCTIONS WHETHER HE COMPLIED WITH NOTIFICATION PROCEDURES OR NOT.

4) Thus, the government's position here encourages the offender not to report the spillage. He who notifies the United States Coast Guard has no odds to play, so - discouragement of reporting spills is inconsistent with the overall regulatory purpose of the Act, which requires the detection of the maximum number of spills, and, therefore, is not compatible with the claim that Paragraph 5 is remedial rather than punitive.

5) The monetary penalty here of $10,000 has been traditionally a measure of criminal punishment.

6) Mandatory imposition, a fact admitted by the United States Coast Guard, the Administering Agent of the Water Pollution Control Act, further convinces the court that Paragraph 5 is a complementary means to criminally punish the wrongdoer rather than regulate "purposeful public policy".

7) The two paragraphs (4, 5) are inextricably intertwined. This could impair the potential offender's guarantee of statutory immunity:

A) The monetary penalty lodged against Le Beouf improperly was sustained upon information obtained via self-disclosure -- this does not support the statutory immunity in Paragraph 4. Actions such as these are prevented by the 5th amendment to the United States Constitution.

B) Although there are cases in which certain civil assessments may connote punishment and be sound, none of these are initiated by a self-disclosure mandate.

C) Paragraph 5 is civil in form but quasi-criminal in nature, because any penalty authorized pursuant to Paragraph 5 is incurred by the commission of offense against the Rivers and Harbors Appropriation Act of 1899.

> *"BARRED FROM PROSECUTING AN OFFENDER UNDER THE RIVERS AND HARBORS APPROPRIATION ACT OF 1899 DUE TO THE FIFTH AMENDMENT AND THE STATUTORY IMMUNITY CLAUSE THE GOVERNMENT CANNOT AFFIX MONETARY PENALTY FOUNDED UPON FRUITS OF SELF-DISCLOSURE"

PRINCIPLE OF LAW:

The Congress may impose both a criminal and civil sanction in respect to the same act.

The Court concurs with the above position in that the penalty granted in §1161 (b) (5) is infirm unless it comports with the use and derivative use of immunity granted in Paragraph 4.

DISPUTE:

The nub of disagreement focuses on the categorization of Paragraph 5, that is, if the penalty authorized by Paragraph 5 is civil in nature, as is contended by the government, or is a criminal sanction, as averred by the defendant and amici curiae. Moreover, the effect of a determination that Paragraph 5 of §1161 is criminal in nature would subject this penalty to the legislative immunity limitations enumerated in Paragraph 4.

REASONING OF THE COURT:

The burden was on the Court to define the regulatory or penal character of the statute, or whether it was civil or criminal. They asked themselves, "Was the aim of legislation to regulate this activity or was the intent to punish the party for engaging in the activity?"

1) There is no clear legislative history to precedent this instance. So the Court used one other case (Kennedy vs Mendoza-Martinez) in its attempt to acquire some more relevant criteria by which to decide. They, thus, did interpret Paragraph 5 as punitive.

2) The Court refers to the term "civil penalty" as merely a label. It says that to be guided by superficial implements such as word classification or legal jargon would be an analytical pitfall, and that in the field of law there is a weakness in dependency on names.

3) This is a Catch 22 situation:

A) Dual penalties are being imposed
  i) failure to notify authorities
  ii) penalty for spill occurrence

A hypothetical situation was posed, in re: drug abuse (dual penalties)

  i) failure to notify authorities of possession
  ii) fine for possession

Say the hypothetical voilator turns himself in, thus immunizing himself from initial criminal punishment -- he still could be penalized by the government under "civil" assessment.

However, this case is in violation of this principle of law because there is no clear legislative expression indicating that Paragraph 4 and 5 of §1161 are penal and remedial respectively, but the Court finds them both disciplinary penalties intended to punish and deter.

DECISION OF COURT:

Paragraph 5 of Section 1161 is criminal in nature. The penalty under Paragraph 5 can only be enforced if supported by independent information, other than via self-disclosure.

$2,500 penalty waived.

Motion for summary judgement grated.

FOOTNOTES TO EXHIBIT A

1. The relevant portions of the law are:

   Title 33 U. S. Code, Section 1161

   (b)(4) The person in charge of vessel, or onshore or offshore facility, upon knowledge of the discharge of oil (or other such violation) must immediately notify the appropriate U. S. agency.

   Failure to notify lends (upon conviction) to a criminal offense - a fine of not more than $10,000 or imprisonment for less than one year, or both.

   Notification received pursuant to this paragraph or information obtained by exploitation of such notification shall not be used against any such person in any criminal case, except in prosecution for perjury or false statements.

   (b)(5) The owner or operator of vessel, or onshore or offshore facility, upon knowledge of the discharge of oil (or other such violation) shall be assessed a CIVIL PENALTY by the secretary of the department in which the United States Coast Guard operates of not more than $10,000 for each offense.

   No penalty assessed unless the owner or operator charged is given notice and the opportunity for hearing on such charge.

   The civil penalty may be compromised by the Secretary.

   Each violation is a separate offense.

2. Summary Judgement:

   A motion for summary judgement is not a trial. It assumes that scrutiny of the facts will disclose that the issues presented by pleadings need not be tried because they are so insubstantial as to not be genuine issues at all.

COMPLIANCE OF THE METHODOLOGIES WITH CONGRESSIONAL INTENT

When it can be determined, the controlling criterion for interpreting legislation should always be the intent of Congress. Legislative intent is normally determined by a thorough reading of the applicable statute, by application of established rules of construction, and by consideration of the legislative history of the statute. The language in Section 311 of the Federal Water Pollution Control Act Amendments of 1972 leaves much discretion to the Administrator of the Environmental Protection Agency and does not make clear exactly how a methodology for determination of harmful quantities and an appropriate penalty schedule for hazardous substances should be determined. Consequently, examination of the legislative history of the Act is appropriate. The legislative history of the Act is helpful in one area because it indicates that Congress was concerned that the penalties in Section 311 might be too severe and that a preferable means of control would be regulations clearly defining requirements for safe handling and shipment of hazardous substances.

Each of the four methodologies developed in the technical portion of this report utilizes various approaches to grouping hazardous substances, selecting harmful quantities, and deriving a penalty schedule. In addition, two of the methodologies offer locational variables which further refine penalty assessments based upon the circumstances of particular spills. The language in Section 311 applicable to each of these categories is rather general and leaves further development up to the Environmental Protection Agency. For example, in determining the penalty schedule, Section 311(b)(2)(B)(iv) of the Act provides that the EPA administrator shall establish a fixed unit of measurement for each hazardous substance based upon usual trade practices, and for each unit a fixed monetary penalty falling between $100 and $1000 based upon "the toxicity, degradability, and disposal characteristics of the substance."

As noted above, the one area where Congressional intent is indicated to some extent in the legislative history of the Act is the philosophy of penalty application. No guidance is available from the reported legislative history to aid in the grouping of hazardous substances or the selection of harmful quantities.

The Congressional intent regarding penalty schedules is indicated in a statement by Representative Robert Roe during debate in the House of Representatives on the Joint Senate-House Conference Bill, which later became the Act, and in the report of the Conference Committee. Representative Roe was one of the House managers in the Conference Committee. His statement regarding Section 311 is quoted in its entirety on the following page.*

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*House Consideration of the Report of the Conference Committee, as reported in Committee on Public Works, 93rd Congress, 1st Session, A Legislative History of the Water Pollution Control Act Amendments of 1972, p. 271 (Committee Print, January 1973).

> *"Section 311 of the report establishes very stringent penalties on the discharge of hazardous substances. The managers did this reluctantly because they feel strongly that clear and effective regulations and laws on the control of the methods of shipping hazardous substances is more desirable than the severe penalty approach which the managers adopted and which commences two years after the enactment of this act.*
>
> *"The protection of our water resources requires that hazardous substances be closely controlled, and in the absence of subsequent legislation by those communities having control of this matter, the stringent penalty provisions would come into effect. The managers recognize, and I emphasize this, that the strict penalty provision is undesirable and we urge the other committees in the Congress with jurisdiction in this area to initiate hearings and develop necessary legislation to control the shipping of hazardous substances at the earliest possible time.*
>
> *"The shipment of hazardous substances is an absolute necessity for our complex industrial economy; thus, it is incumbent upon the Congress to clearly define the controls and requirements for the safe shipment of these hazardous substances."*

Representative Roe's statement indicates that the Conference Committee was generally opposed to a strict penalty schedule and favored regulations to control the handling and transportation of hazardous substances. His statement is consistent with the report of the Conference Committee:

> *"The conferees hope that during the next two years the appropriate committees of the Congress will consider the need for legislation to improve methods of storing, shipping, and handling hazardous substances which cannot be removed from the water. If such legislation is enacted, the conferees agree that the liability provisions of this section will be reviewed and necessary changes proposed by the Committee on Public Works."*[5]

The preceding remarks suggest that less severe penalty schedules may be deemed as the most responsive to Congressional intent regarding the imposition of penalties if, at the same time, they can be shown to have a positive effect.

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[5] Senate Conference Report No. 92-1236, 92nd Congress, 2nd Session, as reported in Committee on Public Works, 93rd Congress, 1st Session, A Legislative History of the Water Pollution Control Act Amendments of 1972, p. 317 (Committee Print, January 1973).

UNIT OF MEASUREMENT

During the development of the technical approaches contained in Volume II, questions arose relating to the interpretation of the phrase, "unit of measurement based upon the usual trade practice." Section 311(b)(2)(B)(iv) states that rates of penalty for individual materials be established as the ratio of this unit of measurement to a fixed monitary amount ranging between $100 and $1000. The law does not relate the procedure to be followed in deriving this rate of penalty. In the technical portion of the report, two alternatives were utilized.

1. In the DOHM, IMCO, and Resource Value Methodologies the rate of penalty was derived as an integral quantity. That is, the ratio of the monitary amount and the unit of measurement were derived together as a single entity.

2. In the Unit of Measurement Methodology the ratio comprising the rate of penalty was formulated from two separate quantities -- a dollar amount of $1000, and a unit of measurement equal to 4000 gallons of IMCO Category D material.

In retrospect, the unit of measurement approach comes closest to complying with the wording of the law; however, as indicated in Chapter VI of this volume, certain technical problems relating to the ability of such an approach to reflect the degree of hazard associated with individual materials are encountered.

The other three approaches rely on a less stringent interpretation of the law. That is, the unit of measurement criteria is applied to the final rate of penalty but is not employed in the derivation of the rate of penalty. Thus, although penalty rates in the DOHM, IMCO, and Resource Value Methodologies are expressed in dollars per kilogram or pound (where the unit of measurement common to the usual trade practice is the kilogram of pound), a unit of measurement as a separate identifiable entity is not present in the derivation of penalty rates under these three approaches.

Correspondence[6] received from the staff of the Senate Subcommittee on Environmental Pollution indicates that Congressional intent was that liability be assessed on a dollar/per unit basis and that the units be expressed in terms which are commonly used in the trade for a particular substance. Correspondence from the Manufacturing Chemists Association[7] verifies the elusiveness of "common trade units" and states that such a unit is not a practical measure for establishing penalties under Section 311.

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[6] Letter from Mr. Leon G. Belling, Senior Staff Member of Senate Subcommittee on Environmental Pollution, March 25, 1974.

Based on the discussion of the technical problems associated with the derivation of the rate of penalty as a ratio of two separate quantities and the supporting documentation received from the Senate Subcommittee staff and the MCA, it is concluded that the approaches used in the DOHM, IMCO, and Resource Value Methodologies meet both the letter and intent of the law and provide a much sounder technical basis for the rates of penalty.

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[7] Letter from Manufacturing Chemists Association, January 24, 1975.

REFERENCES

1. Louis, F. A. "Water Quality Insurance Syndicate," addressed before the Houston Marine Seminar, October 1971.
2. Correspondence with WQIS, September 1974 (also available in Best's Insurance Guide).
3. Interview with Gordon Paulsen, Haight, Gardner, Poor and Havens, New York, New York, September 5, 1974.
4. House Consideration of the Report of the Conference Committee, as reported in Committee on Public Works, 93rd Congress, 1st Session, A Legislative History of the Water Pollution Control Act Amendments of 1972, p. 271 (Committee Print, January 1973).
5. Senate Conference Report No. 92-1236, 92nd Congress, 2nd Session, as reported in Committee on Public Works, 93rd Congress, 1st Session, A Legislative History of the Water Pollution Control Act Amendments of 1972, p. 317 (Committee Print, January 1973).
6. Letter from Mr. Leon G. Belling, Senior Staff member of Senate Subcommittee on Environmental Pollution, March 25, 1974.
7. Letter from Manufacturing Chemists Association, January 24, 1975.

APPENDIX A

DERIVATION OF REPRESENTATIVE BARGE OPERATION

As indicated in Chapter IV, annual financial and operating statistics on U. S. barging operations are for the most part not a matter of public record since most barging companies are not regulated by the Interstate Commerce Commission. For this reason it was necessary to "derive" these figures and from this derivation construct a profile for an average barge operator. As an aid to the reader, Figure IV-3 (shown here as Figure A-1) from Chapter IV has been included in the Appendix as an aid to the reader in following the step of the derivation. Steps in this figure are numbered in the order they appear in the text.

TOWBOAT AND BARGE OPERATING COSTS

The size of towboats operating in the lower Mississippi Area is quite varied, ranging from 800 to 6600 horsepower. Therefore, it was felt necessary to estimate hourly operating costs of towboats for a variety of sizes. The hourly operating costs are assumed to be made up of two components:

1. Fixed Costs which are a function of time, rather than the level of activity. These costs relate to the investment based for a towboat and contain the following items:
    - Return on Investment
    - Depreciation
    - Administration and Supervision
2. Operating Costs are a function of the level of activity and include the following seven items:
    - Wages and Fringe Benefits
    - Fuel
    - Maintenance and Repairs
    - Supplies
    - Subsistence
    - Insurance
    - Miscellaneous Operating Costs

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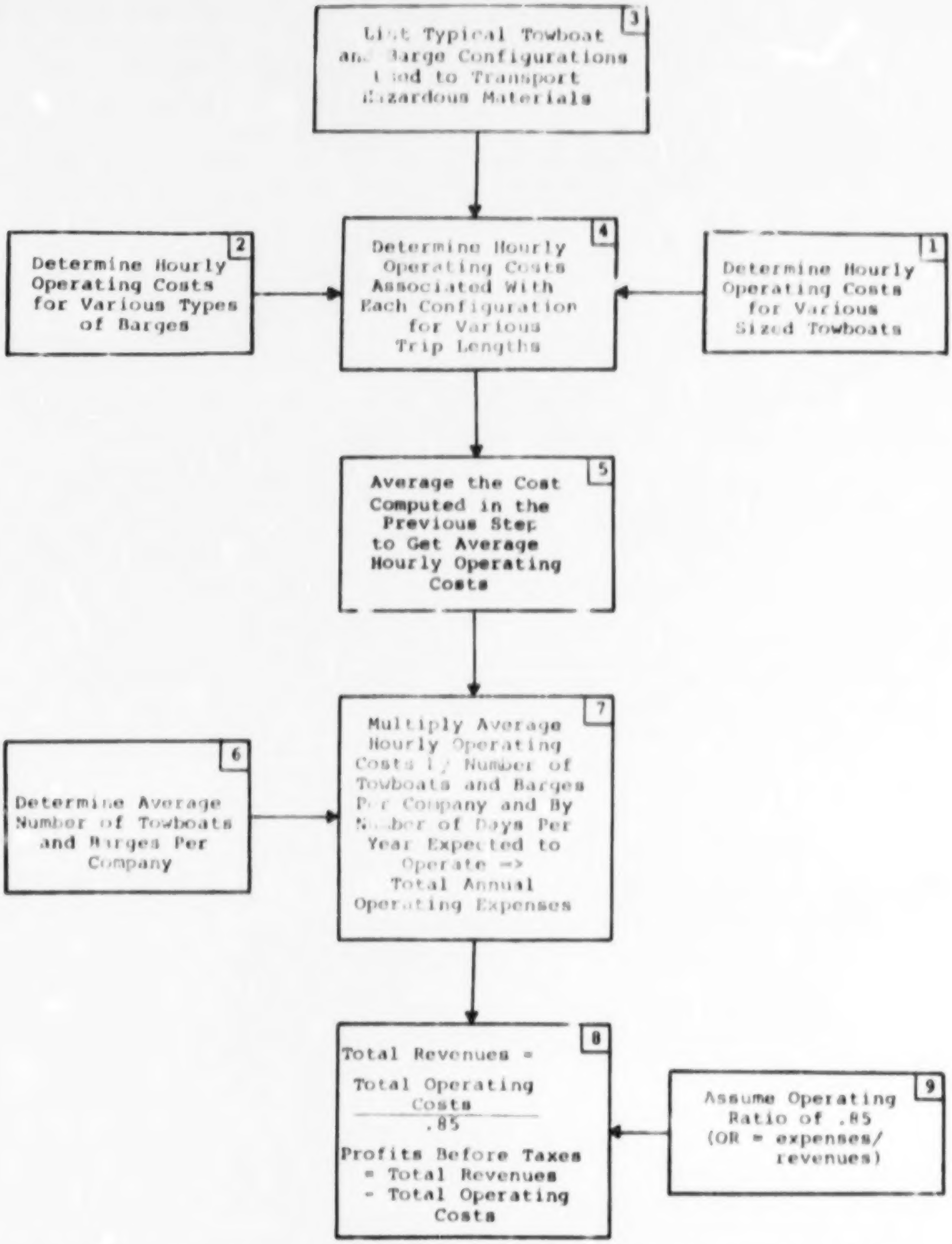
3
List Typical Towboat and Barge Configurations Used to Transport Hazardous Materials
2
Determine Hourly Operating Costs for Various Types of Barges
4
Determine Hourly Operating Costs Associated With Each Configuration for Various Trip Lengths
1
Determine Hourly Operating Costs for Various Sized Towboats
5
Average the Cost Computed in the Previous Step to Get Average Hourly Operating Costs
6
Determine Average Number of Towboats and Barges Per Company
7
Multiply Average Hourly Operating Costs By Number of Towboats and Barges Per Company and By Number of Days Per Year Expected to Operate => Total Annual Operating Expenses
8
Total Revenues = Total Operating Costs / .85
Profits Before Taxes = Total Revenues - Total Operating Costs
9
Assume Operating Ratio of .85 (OR = expenses/ revenues)

FIGURE A-1. PROCEDURE FOR ESTIMATING BARGE OPERATING COSTS

Table A-1 presents estimated costs as of 1972 of operating common and contract carrier towboats on the Mississippi River system.

The variety of barge sizes makes it necessary to estimate hourly operating costs for a selected sample of barge types. For ammonia, caustic soda, and liquid sulfur barges, costs are estimated for a small and a large size barge. For chlorine only the most typical size is considered. The hourly operating costs are presented in Table A-2.

TOW COST ESTIMATES

Transportation costs by barge vary as the trip length changes. This is because of the spread of fixed loading and unloading times at ports for different levels of ton-miles per trip. For a specific barge configuration, per ton transportation costs, can be estimated for different trip lengths by using the cost data from Tables A-1 and A-2, and trip hour data from Table A-3. Costs would also vary by the tow type assumed. For example, given the same trip length an 800 HP towboat pushing two 900 ton ammonia barges would have a cost different from a 1200 HP towboat pushing the same configuration of barges. A representative set of two types are developed to calculate transport costs per ton, and ton-mile. Table A-4 shows the typical tow types considered and hourly operating costs in the Lower Mississippi Area. For each tow type and line haul distance combination, a transportation cost per ton and ton-mile is computed. Tables A-5 thru A-10 present the details of these cost estimates. These tables show that given a specific trip length costs per ton or ton-mile significantly change as the type of tow is changed. For example, Table A-5 shows that, of the six anhydrous ammonia tows considered, cost per ton-mile for a trip length of 300 miles changes from 8.9 (for tow type 6) to 23.1 (for tow type 5) mills. The corresponding figures per ton are $2.67 and $6.94. Costs for chlorine, sulfuric acid, and caustic soda tows shows similar variations.

AVERAGE REVENUES AND EXPENSES

Representative hourly barge operating expenses were derived by averaging the costs associated with selected tow types shown in Tables A-5 thru A-10. For ammonia, tow types 5 and 6 were used; for chlorine, 9 and 10; for caustic soda, 14 and 15; and for sulfuric acid, 20 and 21. Close inspection of these tables will indicate that these two types represent the high and low ends of the cost range for each of the four chemicals. These numbers are averaged over trip length and chemical type to yield a final average operating cost of $93.30 per hour. This figure can be broken down as follows:

TABLE A-1

1972 ESTIMATED COSTS OF OPERATING COMMON CARRIER TOWBOATS ON MISSISSIPPI RIVER SYSTEM[1,2]

HORSEPOWER	800	1,000	1,200	1,400
INVESTMENT (Average New Cost)	$330,000	$375,000	$450,000	$500,000
FIXED COSTS:				
Return on investment (8%)	$ 26,400	$ 30,000	$ 36,000	$ 40,000
Depreciation (20 year straight line; 5% salvage)	15,675	17,813	21,375	22,500
Administration and supervision	21,400	22,700	25,000	26,100
Sub-Total	$ 63,475	$ 70,513	$ 82,375	$ 88,600
OPERATING COSTS:				
Wages & fringe benefits	$156,000	$156,000	$169,000	$169,000
Fuel	27,000	34,000	41,000	48,000
Maintenance, repairs & electronics	15,600	18,800	21,900	25,000
Supplies	6,400	7,000	7,500	7,800
Subsistence	8,000	8,000	9,200	9,200
Insurance	6,000	7,000	8,000	9,000
Miscellaneous	600	600	750	750
Sub-Total	$219,600	$231,400	$257,350	$268,750
TOTAL COSTS:	$283,075	$301,913	$339,725	$357,350
HOURLY OPERATING COST: (Rounded) (345 days)	$ 34.00	$ 37.00	$ 41.00	$ 43.00
ESTIMATED CREW (Average):	7	7	8	8

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[1] Jacobson, I. B., System Analysis of Obstructive Bridges, U. S. Coast Guard Academy

[2] U. S. Department of Transportation, DOT Superport Study, Interim Report, Appendix G.

TABLE A-1 (Cont'd.)

1972 ESTIMATED COSTS OF OPERATING COMMON CARRIER TOWBOATS ON MISSISSIPPI RIVER SYSTEM

HORSEPOWER	1,600	1,800	2,000	2,200	2,400
INVESTMENT (Average New Cost)	$575,000	$625,000	$675,000	$750,000	$800,000
FIXED COSTS:					
Return on investment (8%)	$ 46,000	$ 50,000	$ 54,000	$ 60,000	$ 64,000
Depreciation (20 year straight line; 5% salvage)	27,313	29,688	32,063	35,625	38,000
Administration and supervision	29,500	30,600	34,000	35,200	36,300
Sub-Total	$102,813	$110,288	$120,063	$130,825	$138,300
OPERATING COSTS:					
Wages & fringe benefits	$190,000	$190,000	$210,000	$210,000	$210,000
Fuel	55,000	62,000	68,000	75,000	82,000
Maintenance, repairs & electronics	28,200	31,200	34,000	36,600	39,400
Supplies	8,300	8,700	9,200	9,700	10,000
Subsistence	10,300	10,300	11,400	11,400	11,400
Insurance	10,000	11,000	12,000	14,600	15,800
Miscellaneous	850	850	950	950	950
Sub-Total	$302,650	$314,050	$345,550	$358,250	$369,550
TOTAL COSTS:	$405,463	$424,338	$465,613	$489,075	$507,850
HOURLY OPERATING COST: (Rounded) (345 days)	$ 49.00	$ 51.00	$ 56.00	$ 59.00	$ 61.00
ESTIMATED CREW (Average)	9	9	10	10	10

TABLE A-1 (Cont'd.)

1972 ESTIMATED COSTS OF OPERATING COMMON CARRIER TOWBOATS ON MISSISSIPPI RIVER SYSTEM

HORSEPOWER	2,600	2,800	3,000	3,200	3,400
INVESTMENT (Average New Cost)	$850,000	$875,000	$950,000	$1,000,000	$1,050,000
FIXED COSTS:					
Return on investment (8%)	$ 68,000	$ 70,000	$ 76,000	$ 80,000	$ 84,000
Depreciation (20 year straight line; 5% salvage)	40,375	41,563	45,125	47,500	49,875
Administration and supervision	39,400	40,500	41,300	42,000	43,800
Sub-Total	$147,775	$152,063	$162,425	$ 169,500	$ 177,675
OPERATING COSTS:					
Wages & fringe benefits	$228,000	$228,000	$228,000	$ 228,000	$ 228,000
Fuel	88,000	95,000	102,000	106,000	115,000
Maintenance, repairs & electronics	42,500	45,000	47,500	50,000	52,500
Supplies	10,500	11,000	11,400	11,500	11,500
Subsistence	12,600	12,600	12,600	12,600	12,600
Insurance	16,800	17,900	18,800	20,000	21,000
Miscellaneous	1,100	1,100	1,200	1,200	1,200
Sub-Total	$399,500	$410,600	$421,500	$ 431,300	$ 441,800
TOTAL COSTS:	$547,275	$562,663	$583,925	$ 600,800	$ 619,475
HOURLY OPERATING COST: (Rounded) (345 days)	$ 66.00	$ 68.00	$ 71.00	$ 73.00	$ 75.00
ESTIMATED CREW (Average)	11	11	11	11	11

TABLE A-1 (Cont'd.)

1972 ESTIMATED COSTS OF OPERATING COMMON CARRIER TOWBOATS ON MISSISSIPPI RIVER SYSTEM

HORSEPOWER	3,600	3,800	4,000	4,200	4,800
INVESTMENT (Average New Cost)	$1,100,000	$1,150,000	$1,200,000	$1,250,000	$1,375,000
FIXED COSTS:					
Return on investment (8%)	$ 88,000	$ 92,000	$ 96,000	$ 100,000	$ 110,000
Depreciation (20 year straight line: 5% salvage)	52,250	54,625	57,000	59,375	65,313
Administration and supervision	45,000	46,200	47,200	48,200	54,200
Sub-Total	$ 185,250	$ 192,825	$ 200,200	$ 207,575	$ 229,513
OPERATING COSTS:					
Wages & fringe benefits	$ 228,000	$ 228,000	$ 228,000	$ 228,000	$ 248,000
Fuel	122,000	129,000	135,000	142,000	164,000
Maintenance, repairs & electronics	55,000	58,700	61,300	63,800	71,300
Supplies	11,500	11,500	11,500	11,500	15,000
Subsistence	12,600	12,600	12,600	12,600	13,700
Insurance	22,000	23,200	24,200	25,000	27,500
Miscellaneous	1,200	1,200	1,200	1,200	1,800
Sub-Total	$ 452,300	$ 464,200	$ 473,800	$ 484,100	$ 541,300
TOTAL COSTS:	$ 637,550	$ 657,025	$ 674,000	$ 691,675	$ 770,813
HOURLY OPERATING COST: (Rounded) (345 days)	$ 77.00	$ 79.00	$ 81.00	$ 84.00	$ 93.00
ESTIMATED CREW (Average)	11	11	11	11	11

TABLE A-1 (Cont'd.)

1972 ESTIMATED COSTS OF OPERATING COMMON CARRIER TOWBOATS ON MISSISSIPPI RIVER SYSTEM

HORSEPOWER	5,000	5,600	6,000	6,500	7,200	8,500-9,000
INVESTMENT (Average New Cost)	$1,450,000	$1,625,000	$1,725,000	$1,900,000	$2,000,000	$2,400,000
FIXED COSTS:						
Return on investment (8%)	$116,000	$130,000	$138,000	$152,000	$160,000	$192,000
Depreciation (20 year straight line; 5% salvage)	68,875	77,188	81,938	90,250	95,000	114,000
Administration and supervision	55,600	58,000	62,700	65,600	67,900	78,700
Sub-Total	$240,475	$265,188	$282,638	$307,850	$322,900	$384,700
OPERATING COSTS:						
Wages & fringe benefits	$248,000	$248,000	$270,000	$270,000	$270,000	$318,000
Fuel	173,000	184,000	200,000	218,000	230,000	250,000
Maintenance, repairs & electronics	74,500	82,500	87,500	93,800	100,000	125,000
Supplies	15,000	16,000	16,500	18,500	19,000	23,000
Subsistence	13,700	13,700	14,800	14,800	14,800	18,300
Insurance	28,800	32,500	34,500	37,500	40,000	47,500
Miscellaneous	1,800	1,800	2,000	2,100	2,200	3,600
Sub-Total	$554,800	$578,500	$625,300	$654,700	$676,000	$785,400
TOTAL COSTS:	$795,275	$843,688	$907,938	$962,550	$998,900	$1,170,100
HOURLY OPERATING COSTS: (Rounded) (345 days)	$ 96.00	$102.00	$110.00	$116.00	$121.00	$141.00
ESTIMATED CREW (Average)	12	12	13	13	13	15

TABLE A-2

1972 ESTIMATED COSTS OF OPERATING BARGES IN THE MISSISSIPPI RIVER SYSTEM--LIQUID CHEMICAL[1,2]

TYPE	DOUBLESKIN		LPG-AMMONIA		CHLORINE	CAUSTIC SODA*		LIQUID SULFUR*	
SIZE	1200 NT 195'x35'	3000 NT 290'x50'	900 NT 210'x44'	2500 NT 240'x50'	1100 NT 195'x35'	1200 NT 195'x35'	3000 NT 260'x50'	1200 NT 195'x35'	3000 NT 230'x50'
INVESTMENT (Average New Cost)	$115,200	$298,000	$355,000	$850,000	$318,000	$150,000	$375,000	$240,000	$600,000
FIXED COSTS:									
Return on investment (8%)	$ 9,200	$ 23,000	$ 28,400	$ 68,000	$ 25,440	$ 12,000	$ 30,000	$ 19,200	$ 48,000
Depreciation (20 years-5% salvage)	5,470	13,680	16,832	40,375	15,105	7,125	17,813	11,400	28,500
Administration (.75% inv.)	864	2,160	2,663	6,375	2,385	1,125	2,813	1,800	4,500
Sub-Total	$ 15,534	$ 38,840	$ 47,925	$114,750	$ 42,930	$ 20,250	$ 50,626	$ 32,400	$ 81,000
OPERATING COSTS:									
Maintenance & repairs (3% of inv.)	$ 3,456	$ 8,640	$ 10,650	$ 25,500	$ 9,540	$ 4,500	$ 11,250	$ 7,200	$ 18,000
Insurance (2% of inv.)	2,304	5,760	7,100	17,000	6,360	3,000	7,500	4,800	12,000
Taxes (.5% of inv.)	576	1,440	1,775	4,250	1,590	750	1,875	1,200	3,000
Miscellaneous	200	400	500	1,200	500	300	500	400	1,000
Sub-Total	$ 6,536	$ 16,240	$ 20,025	$ 47,950	$ 17,990	$ 8,550	$ 21,125	$ 13,600	$ 34,000
TOTAL COSTS:	$ 12,070	$ 55,080	$ 67,950	$162,700	$ 60,920	$ 28,800	$ 71,751	$ 46,000	$115,000
HOURLY OPERATING COST: (Rounded)(345 days)	$ 1.50	$ 6.70	$ 8.20	$ 19.70	$ 7.40	$ 3.50	$ 8.70	$ 5.60	$ 13.90

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*Coiled, insulated, and rubber lined
+Coiled and insulated

TABLE A-3

TOTAL TRIP HOURS FOR A REPRESENTATIVE SAMPLE OF TRIP LENGTHS

TRIP LENGTH (Statute Miles)	300	400	500	1000	1500	2000
Loading Time (Hours)1/	30	30	30	30	30	30
Running Time, upbound at 5 MPH (Hours)2/	60	80	100	200	300	400
Unloading Time (Hours)3/	37	37	37	37	37	37
Running Time, downbound at 12.0 MPH (Hours)2/	25	33	42	84	126	168
Total Hours	152	180	204	351	493	635
Delay Factor (15%) (Hours)4/	23	27	31	53	74	95
Total Hours for Trip	175	207	240	404	567	730

1/ Loading time varies from 24 hours for ammonia, sulfuric acid and caustic soda barges to 50 hours for chlorine barges. The hours estimate is based on the average for these commodities.

2/ Average speed estimates are taken from Table 7.

3/ Average of 24 hours for caustic soda, ammonia, and sulfuric acid and 72 hours for chlorine.

4/ Delay due to weather, river, and other conditions.

TABLE A-4

LIST OF TOW TYPES CONSIDERED

Tow Type No.	Size of Tow Boat (HP)	Barge			Operating Costs Per Hour ($)			Total Carrying Capacity (NT)
		Type	Size (NT)	Number In Tow	Towboat[1/]	Barge[2/]	Total	
1	1000	Double Skin	1200	2	37.00	3.00	40.00	2,400
2	2000	Double Skin	3000	3	56.00	20.10	76.10	9,000
3	1000	Ammonia	900	2	37.00	16.40	53.40	1,800
4	4000	Ammonia	900	3	81.00	24.60	105.60	2,700
5	6000	Ammonia	900	4	110.00	32.80	142.80	3,600
6	1000	Ammonia	2500	2	37.00	39.40	76.40	5,000
7	4000	Ammonia	2500	3	81.00	59.10	140.10	7,500
8	6000	Ammonia	2500	4	110.00	78.80	188.80	10,000
9	1000	Chlorine	1100	2	37.00	14.80	51.80	2,200
10	4000	Chlorine	1100	3	81.00	23.40	104.40	3,300
11	6000	Chlorine	1100	4	110.00	29.60	139.60	4,400
12	1000	Caustic Soda	1200	2	37.00	7.00	44.00	2,400
13	4000	Caustic Soda	1200	3	81.00	10.50	91.50	3,600
14	6000	Caustic Soda	1200	4	110.00	14.00	124.00	4,800
15	1000	Caustic Soda	3000	2	37.00	17.40	54.40	6,000
16	4000	Caustic Soda	3000	3	81.00	26.10	107.10	9,000
17	6000	Caustic Soda	3000	4	110.00	34.80	144.80	12,000
18	1000	Sulfuric Acid	1200	2	37.00	11.20	48.20	2,400
19	4000	Sulfuric Acid	1200	3	81.00	16.80	97.80	3,600
20	6000	Sulfuric Acid	1200	4	110.00	22.40	132.40	4,800
21	1000	Sulfuric Acid	3000	2	37.00	27.80	64.80	6,000
22	4000	Sulfuric Acid	3000	3	81.00	41.70	122.70	9,000
23	6000	Sulfuric Acid	3000	4	110.00	55.60	165.60	12,000

[1/] From Table IV-14

[2/] From Table IV-15

TABLE A-5

BARGE OPERATING COSTS PER TON AND PER TON-MILE AT DIFFERENT TOW TYPES FOR A LINE HAUL DISTANCE OF 300 MILES

Tow Type Number 1/	Chemical Substance	Cost Per Hour 2/	Total Tons 3/	Total Ton Miles (1000)	Total Hours 4/	Cost Per Ton($)	Cost Per Ton Mile (Mils)	Total Cost $
1	--	40.00	2,400	720	175	2.92	9.7	7,000
2	--	76.10	9,000	2,700	175	1.48	4.9	13,317
3	Ammonia	53.40	1,800	540	175	5.19	17.3	9,345
4	Ammonia	105.60	2,700	810	175	6.84	22.8	18,480
5	Ammonia	142.80	3,600	1,080	175	6.94	23.1	24,990
6	Ammonia	76.40	5,000	1,500	175	2.67	8.9	13,370
7	Ammonia	140.00	7,500	2,250	175	3.27	10.9	24,618
8	Ammonia	188.80	10,000	3,000	175	3.30	11.0	33,040
9	Chlorine	51.80	2,200	600	175	4.12	13.7	9,065
10	Chlorine	104.40	3,300	990	175	5.54	18.5	18,270
11	Chlorine	139.60	4,400	1,320	175	5.55	18.5	24,430
12	Caustic Soda	44.00	2,400	720	175	3.21	10.7	7,700
13	Caustic Soda	91.50	3,600	1,080	175	4.45	14.8	16,013
14	Caustic Soda	124.00	4,800	1,440	175	4.52	15.1	21,700
15	Caustic Soda	54.40	6,000	1,800	175	1.59	5.3	9,520
16	Caustic Soda	107.10	9,000	2,700	175	2.08	6.9	18,743
17	Caustic Soda	144.80	12,000	3,600	175	2.11	[illegible]	25,340
18	Sulfuric Acid	48.20	3,400	720	175	3.51	11.7	8,345
19	Sulfuric Acid	97.80	3,600	1,080	175	4.75	15.8	17,115
20	Sulfuric Acid	132.40	4,800	1,440	175	4.83	16.1	23,170
21	Sulfuric Acid	64.80	6,000	1,800	175	1.89	6.3	11,340
22	Sulfuric Acid	122.70	9,000	2,700	175	2.39	9.0	21,473
23	Sulfuric Acid	165.60	12,000	3,600	175	2.42	8.1	28,980

1/ For a description of the tow types see Table A-4

2/ From Table A-1 and A-2

3/ Total tons multiplied by trip length

4/ From Table A-3

TABLE A-6

BARGE OPERATING COSTS PER TON AND PER TON-MILE AT DIFFERENT TOW TYPES FOR A LINE HAUL DISTANCE OF 400 MILES

Tow Type Number 1/	Chemical Substance	Cost Per Hour 2/ ($)	Total Tons 3/	Total Ton Miles (1000)	Total Hours 4/	Cost Per Ton ($)	Cost Per Ton Mile (Mils)	Total Cost $
1	--	40.00	2,400	960	207	3.45	8.6	8,280
2	--	76.10	9,000	3,600	207	1.75	4.4	15,753
3	Ammonia	53.40	1,800	720	207	6.14	15.4	11,054
4	Ammonia	105.60	2,700	1,080	207	8.10	20.3	21,859
5	Ammonia	142.80	3,600	1,440	207	8.21	20.5	29,560
6	Ammonia	76.40	5,000	2,000	207	3.16	7.9	15,815
7	Ammonia	104.00	7,500	3,000	207	3.87	9.7	29,000
8	Ammonia	188.80	10,000	4,000	207	3.91	9.8	39.082
9	Chlorine	51.80	2,200	880	207	4.87	12.2	10,723
10	Chlorine	104.40	3,300	1,320	207	6.55	16.4	21,611
11	Chlorine	139.60	4,400	1,760	207	6.57	16.4	28,897
12	Caustic Soda	44.00	2,400	960	207	3.80	9.5	9,108
13	Caustic Soda	91.50	3,600	1,440	207	5.26	13.2	18.941
14	Caustic Soda	124.00	4,800	1,920	207	5.35	13.4	25,668
15	Caustic Soda	54.40	6,000	2,400	207	1.88	4.7	11,261
16	Caustic Soda	107.10	9.000	3,600	207	2.46	6.2	22,170
17	Caustic Soda	144.80	12,000	4,800	207	2.50	6.3	29,974
18	Sulfuric Acid	48.20	3,400	960	207	4.16	10.4	9,977
19	Sulfuric Acid	97.80	3,600	1,440	207	5.62	14.1	20,245
20	Sulfuric Acid	132.40	4,800	1,920	207	5.71	14.3	27,407
21	Sulfuric Acid	64.80	6,000	2,400	207	2.24	5.6	13,414
22	Sulfuric Acid	122.70	9,000	3,600	207	2.82	7.1	25,199
23	Sulfuric Acid	165.60	12,000	4,800	207	2.87	7.2	34,279

1/ For a description of the tow types see Table A-4

2/ From Table -1 and A-2

3/ Total tons multiplied by trip length

4/ From Table A-3

TABLE A-7

BARGE OPERATING COSTS PER TON AND PER TON-MILE AT DIFFERENT TOW TYPES FOR A LINE HAUL DISTANCE OF 500 MILES

Tow Type Number1/	Chemical Substance	Cost Per Hour2/ ($)	Total Tons3/	Total Ton Miles (1000)	Total Hours4/	Cost Per Ton ($)	Cost Per Ton Mile (Mils)	Total Cost $
1	--	40.00	2,400	1,200	240	4.00	8.0	9,600
2	--	76.10	9,000	4,500	240	2.03	4.1	18,264
3	Ammonia	53.40	1,800	900	240	7.12	14.2	12,816
4	Ammonia	105.60	2,700	1,350	240	9.39	18.8	25,344
5	Ammonia	142.80	3,600	1,800	240	9.52	19.0	34,272
6	Ammonia	76.40	5,000	2,500	240	3.67	7.3	18,336
7	Ammonia	104.00	7,500	3,750	240	4.48	9.0	33,624
8	Ammonia	188.80	10,000	5,000	240	4.53	9.1	45,312
9	Chlorine	51.80	2,200	1,100	240	5.65	11.3	12,432
10	Chlorine	104.40	3,300	1,650	240	7.59	15.2	25,056
11	Chlorine	139.60	4,400	2,200	240	7.61	15.2	33,504
12	Caustic Soda	44.00	2,400	1,200	240	4.40	8.8	10,560
13	Caustic Soda	91.50	3,600	1,800	240	6.10	12.2	21,960
14	Caustic Soda	124.00	4,800	2,400	240	6.20	12.4	29,760
15	Caustic Soda	54.40	6,000	3,000	240	2.18	4.4	13,056
16	Caustic Soda	107.10	9,000	4,500	240	2.97	5.7	25,704
17	Caustic Soda	144.80	12,000	6,000	240	2.90	5.8	34,752
18	Sulfuric Acid	48.20	2,400	1,200	240	4.82	9.6	11,568
19	Sulfuric Acid	97.80	3,600	1,800	240	6.52	13.0	23,372
20	Sulfuric Acid	132.40	4,800	2,400	240	6.62	13.2	31,776
21	Sulfuric Acid	64.80	6,000	3,000	240	2.59	5.2	15,552
22	Sulfuric Acid	122.70	9,000	4,500	240	3.27	6.5	29,448
23	Sulfuric Acid	165.00	12,000	6,000	240	3.31	6.6	39,744

1/ For a description of the tow types see Table A-4

2/ From Table A-1 and A-2

3/ Total tons multiplied by trip length

4/ From Table A-3

TABLE A-8

BARGE OPERATING COSTS PER TON AND PER TON-MILE AT DIFFERENT TOW TYPES FOR A LINE HAUL DISTANCE OF 1000 MILES

Tow Type Number1/	Chemical Substance	Cost Per Hour2/ ($)	Total Tons3/	Total Ton Miles (1000)	Total Hours4/	Cost Per Ton ($)	Cost Per Ton Mile (Mils)	Total Cost $
1	--	40.00	2,400	2,400	404	6.73	6.7	16,160
2	--	76.10	9,000	9,000	404	3.42	3.4	30,744
3	Ammonia	53.40	1,800	1,800	404	11.99	12.0	21,574
4	Ammonia	105.60	2,700	2,700	404	15.80	15.8	42,662
5	Ammonia	142.80	3,600	3,600	404	16.02	16.0	57,691
6	Ammonia	76.40	5,000	5,000	404	6.17	6.2	30,866
7	Ammonia	140.00	7,500	7,500	404	7.55	7.6	56,600
8	Ammonia	188.80	10,000	10,000	404	7.63	7.6	76,275
9	Chlorine	51.80	2,200	2,200	404	9.51	9.5	20,927
10	Chlorine	104.40	3,300	3,300	404	12.78	12.8	42,178
11	Chlorine	139.60	4,400	4,400	404	12.82	12.8	56,398
12	Caustic Soda	44.00	2,400	2,400	404	7.41	7.4	17,776
13	Caustic Soda	91.50	3,600	3,600	404	10.27	10.3	36,966
14	Caustic Soda	124.00	4,800	4,800	404	10.44	10.4	50,096
15	Caustic Soda	54.40	6,000	6,000	404	3.7	3.7	21,978
16	Caustic Soda	107.10	9,000	9,000	404	4.81	4.8	43,268
17	Caustic Soda	144.80	12,000	12,000	404	4.87	4.9	58,499
18	Sulfuric Acid	48.20	2,400	2,400	404	8.11	8.1	19,473
19	Sulfuric Acid	97.80	3,600	3,600	404	10.98	11.0	39,511
20	Sulfuric Acid	132.40	4,800	4,800	404	11.14	11.1	53,490
21	Sulfuric Acid	64.80	6,000	6,000	404	4.36	4.4	26,179
22	Sulfuric Acid	122.70	9,000	9,000	404	5.51	5.5	49,571
23	Sulfuric Acid	165.60	12,000	12,000	404	5.58	5.6	66,902

1/ For a description of the tow types see Table A-4

2/ From Table A-1 and A-2

3/ Total tons multiplied by trip length

4/ From Table A-3

TABLE A-9

BARGE OPERATING COSTS PER TON AND PER TON-MILE AT DIFFERENT TOW TYPES FOR A LINE HAUL DISTANCE OF 1500 MILES

Tow Type Number1/	Chemical Substance	Cost Per Hour2/ ($)	Total Tons2/	Total Ton Miles (1000)	Total Hours4/	Cost Per Ton($)	Cost Per Ton Mile (Mils)	Total Cost $
1	--	40.00	2,400	3,600	567	9.45	6.3	22,680
2	--	76.10	9,000	13,500	567	4.79	3.2	43,149
3	Ammonia	53.40	1,800	2,700	567	16.82	11.2	30,278
4	Ammonia	105.60	2,700	4,050	567	22.18	14.8	59,875
5	Ammonia	142.80	3,600	5,400	567	22.49	15.0	80,968
6	Ammonia	76.40	5,000	7,500	567	8.66	5.8	43,319
7	Ammonia	140.00	7,500	11,250	567	10.59	7.1	79,437
8	Ammonia	188.80	10,000	15,000	567	10.71	7.1	107,050
9	Chlorine	51.80	2,200	3,300	567	13.35	8.9	29,371
10	Chlorine	104.40	3,300	4,950	567	17.94	12.0	59,195
11	Chlorine	139.60	4,400	6,600	567	17.99	12.0	79,153
12	Caustic Soda	44.00	2,400	3,600	567	10.40	6.9	24,948
13	Caustic Soda	91.50	3,600	5,400	567	14.41	9.6	51,881
14	Caustic Soda	124.00	4,800	7,200	567	14.65	9.8	70,308
15	Caustic Soda	54.40	6,000	9,000	567	5.14	3.4	30,845
16	Caustic Soda	107.10	9,000	13,500	567	6.75	4.5	60,726
17	Caustic Soda	144.80	12,000	18,000	567	6.84	4.6	82,102
18	Sulfuric Acid	48.20	2,400	3,600	567	11.39	7.6	27,329
19	Sulfuric Acid	97.80	3,600	5,400	567	15.40	10.3	55,453
20	Sulfuric Acid	132.40	4,800	7,200	567	15.64	10.4	75,071
21	Sulfuric Acid	64.80	6,000	9,000	567	6.12	4.1	36,742
22	Sulfuric Acid	122.70	9,000	13,500	567	7.73	5.2	69,571
23	Sulfuric Acid	165.60	12,000	18,000	567	7.82	5.2	93,895

1/ For a description of the tow types see Table A-4

2/ From Table A-1 and A-2

3/ Total tons multiplied by trip length

4/ From Table A-3

TABLE A-10

BARGE OPERATING COSTS PER TON AND PER TON-MILE AT DIFFERENT TOW TYPES FOR A LINE HAUL DISTANCE OF 2000 MILES

Tow Type Number[1/]	Chemical Substance	Cost Per Hour[2/] ($)	Total Tons[3/]	Total Ton Miles (1000)	Total Hours[4/]	Cost Per Ton ($)	Cost Per Ton Mile (Mils)	Total Cost $
1	--	40.00	2,400	4,800	730	12.17	6.1	29,200
2	--	76.10	9,000	18,000	730	6.17	3.1	55,553
3	Ammonia	53.40	1,800	3,600	730	21.66	10.8	38,982
4	Ammonia	105.60	2,700	5,400	730	28.55	14.3	77.088
5	Ammonia	142.80	3,600	7,200	730	28.96	14.5	104,244
6	Ammonia	76.40	5,000	10,000	730	11.15	5.6	55,772
7	Ammonia	140.00	7,500	15,000	730	13.64	6.8	102,273
8	Ammonia	188.80	10,000	20,000	730	13.78	6.9	137,924
9	Chlorine	51.80	2,200	4,400	730	17.19	8.6	37,814
10	Chlorine	104.40	3,300	6,600	730	23.09	11.5	76,212
11	Chlorine	139.60	4,400	8,800	730	23.16	11.6	101,908
12	Caustic Soda	44.00	2.400	4,800	730	13.38	6.7	32.120
13	Caustic Soda	91.50	3,600	7,200	730	18.55	9.3	66,795
14	Caustic Soda	124.00	4,800	9,600	730	18.86	9.4	90,520
15	Caustic Soda	54.40	6,000	12,000	730	6.62	3.3	39,712
16	Caustic Soda	107.10	9,000	18,000	730	8.69	4.3	78,183
17	Caustic Soda	144.80	12,000	24,000	730	8.81	4.4	105,704
18	Sulfuric Acid	48.20	2,400	4,800	730	14.66	7.3	35,186
19	Sulfuric Acid	97.80	3,600	7,200	730	19.83	9.9	71,394
20	Sulfuric Acid	132.40	4,800	9,600	730	20.14	10.1	96,652
21	Sulfuric Acid	64.80	6,000	12,000	730	7.88	3.9	47,307
22	Sulfuric Acid	122.70	9,000	18,000	730	9.95	5.0	89,571
23	Sulfuric Acid	165.60	12,000	24,000	730	10.07	5.0	120,888

1/ For a description of the tow types see Table A-4

2/ From Table A-1 and A-2

3/ Total tons multiplied by trip length

4/ From Table A-3

Towboat	$70.00 per hour
Barges	$ 8.33 per hour per barge
Average barges per tow	$ 2.88

It was previously noted that a total of 1700 companies operate 3800 towboats and 16,600 barges in the United States. The national average per company is 2.24 towboats and 9.76 barges. Assuming 345 working days per year, the average operating costs per barge operator is estimated at around $2 million per year. Assuming an operating ratio of 0.85[3] this translates to an average operating revenue of $2,325 thousand per year, leaving an estimated operating income of $325,000.

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[3] *Transportation Statistics in the United States, Carriers by Water*, Interstate Commerce Commission, December 1971.

REFERENCES

1. Jacobson, I. B. "Systems Analysis of Abstructive Bridges," U. S. Coast Guard Academy.

2. U. S. Department of Transportation, D.O.T. Superport Study, Interum Report, Appendix G.

3. Transportation Statistics in the United States, Carriers by Water, Interstate Commerce Commission, December 1971.

U.S. GOVERNMENT PRINTING OFFICE 1975— 582 423 281